CHINA CLASSIFICATION SOCIETY

RULES FOR CONSTRUCTION OF COASTAL BOATS

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CONTENTS

Chapter 1 GENERAL

Section 1 General Requirements

1.1.1 Application

1.1.1.1 The Rules applies to classed sea-going boats of less than 20 m in length, and does not apply to:

(1) boats of war;

(2) wooden boats;

(3) yachts not engaged in trade①;

(4) oil tanker carrying oil having a flash point of less than 60℃;

(5) boats carrying dangerous goods (including bulk chemical carrier and liquefied gas carrier);

(6) submerged and semi-submerged boats;

(7) small water-plane area twin-hull boats;

(8) sports boats; and

(9) fishing boats.

1.1.1.2 The service restriction for boats applicable to the Rules is specified as follows:

(1) Coastal service restriction means the service in the sea area within 20 n miles off the shore (not exceeding 10 n miles in Taiwan Strait and similar waters), and a passenger boat does not proceed in the course of its voyage more than 4 h, or a cargo boat 8 h, at 90% of the maximum speed from a place of refuge② when fully laden. Where the sea state of some service areas above-mentioned is heavier, more stringent requirements may be made by the Society to the distance above-mentioned, depending on the specific cases. When special provisions for the service area are stipulated by the Administration of the flag State or by the coastal Authority in charge of the service area, the provisions are to be observed.

(2) Sheltered water service restriction means the service in the sea area between the island and the shore and between islands with a distance of less than 10 n miles in between, which form a comparatively good sheltered condition with a little wave, or within 10 n miles off the shore (not exceeding 5 n miles in Taiwan Strait and similar waters), and a passenger boat does not proceed in the course of its voyage more than 2 h, or a cargo boat 4 h, at 90% of the maximum speed when fully laden, Beaufort wind scale not more than 6 scale, and the visual wave height not more than 2.0 m in sea state.

(3) Calm water service restriction means the calm water service within 5 n miles off the shore and a boat does not proceed in the course of its voyage more than 2 h at 90% of the maximum speed when fully laden, Beaufort wind scale not more than 6 scale, and visual wave height not more than 1.0 m in sea state.

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① Yacht not engaged in trade means the yacht not for commercial purposes.

② Place of refuge is any naturally or artificially sheltered area which may be used as a shelter by a boat under conditions likely to endanger its safety.

1.1.1.3 Operation of open boat is only limited in the condition of calm water service restriction. High speed open boat is not permitted to carry more than 12 passengers.

1.1.1.4 The materials for boats applicable to the Rules may be of steel, aluminum alloy or fabric reinforced plastics. The materials and construction technology of boats are to be in compliance with the relevant requirements of Rules for Materials and Welding by China Classification Society (hereinafter referred to as CCS or the Society).

1.1.1.5 Motor boats applicable to the Rules are those mainly driven by engines with diesel oil, petrol or liquefied petrol gas (hereinafter referred to as LPG) as fuel.

1.1.1.6 The existing boats after repair, alteration and modification are at least to be in compliance with the applicable requirements of the original corresponding rules. Where major repair, alternation and modification are made, such boats are to comply with the requirements of the Rules in so far as reasonable and practicable.

1.1.1.7 The stability, fire safety, life-saving appliances and communications, etc. of boats are to comply with the requirements of the flag State Administration relating to safety equipment and environmental protection.

1.1.1.8 Where the decimal part of the calculated plate thickness in the Rules is 0.25 mm or less, it may be neglected; where it is greater than 0.25 mm but less than 0.75 mm, it is to be taken as 0.5 mm; where it is 0.75 mm or more, a round number of 1.0 mm is to be taken.

1.1.2 Definitions

1.1.2.1 Unless expressly provided otherwise, for the purpose of the Rules:

(1) Overall length L_{oa} (m) means a distance from the fore end of stem to the aft edge of stern transom plating or sternpost, excluding any other protrusions.

(2) Length L (m) means the length between the forward stem post and after rudder post along the full load waterline of a boat, or the length between the forward stem post and the center line of the rudder stock for a boat without rudderpost.

(3) Full-load displacement $\triangle$ (t) means the weight of sea water displaced by a boat under an immediate sailing condition with the required equipment, cargo stores, accessories, rigging, crew, etc., 100% of fuel oil, lubricating oil , fresh water, food, supplies and rated passengers onboard the boat.

(4) Full load draft d (m) means the vertical distance measured at the midpoint of length (L) from the top of the plate keel (or from the lower surface of keel for fabric reinforced plastics boat) to the full load waterline of a boat at full-load displacement in rest floatation.

(5) Breadth B (m) means the horizontal distance measured from the outside of the boat frame of one to that of other side; or the maximum breadth between two sides of external surfaces for fabric reinforced plastics boat, at the widest part of a boat, excluding protrusions, fenders, etc.

(6) Moulded depth D (m) means the vertical distance measured at the middle of the length L from the top of the plate keel to the top of the deck beam at side on the uppermost continuous deck (for decked boat) or to the top end of the shell side plating (for open boat). For fabric reinforced plastics boat, the vertical distance measured at the midpoint of length (L) from the lower surface of the plate keel to the top of the uppermost continuous deck (for decked boat) or to the top end of the shell side plating (for open boat).

(7) Freeboard F (m) means the vertical distance measured from the full load waterline to the top of freeboard deck (for decked boat) or to the top end of the shell side plating (for open boat).

(8) Freeboard deck means a continuous weather deck from bow to stern on decked boat.

(9) High speed boat means a boat capable of a maximum speed V meeting both the following formulae at its full-load displacement:

$$V \geqslant 3.7 \nabla^{0.1667} \quad \text{m/s}$$

$$V \geqslant 10 \quad \text{kn}$$

where: ∇— displacement corresponding to its full-load displacement, in m^3;
V— speed achieved at its maximum continuous propulsion power for which the boat is certified at its full-loaded displacement and in smooth water.

(10) Maximum speed is the speed achieved at the maximum continuous propulsion power for which the boat is certified at maximum operational weight and in smooth water.

(11) Yacht means a boat engaged in trade for public entertainment, leisure or touring.

(12) Decked boat means a small boat having a continuous weathertight deck from bow to stern.

(13) Open boat means a small boat not having a continuous weathertight deck from bow to stern.

(14) Public boat means a working boat intended for patrol, customs and police service, etc.

(15) Passenger boat means a boat carrying more than 12 passengers.

(16) A passenger is every person other than:

① the master and the members of the crew or other persons employed or engaged in any capacity on board a boat on the business of that boat; and

② a child under one year of age.

(17) Cargo boat means any boat other than passenger boat.

1.1.3 Equivalent and exemption

1.1.3.1 Any boat which embodies structure and features of a novel kind may be exempted from any requirement of the Rules if the application of which might seriously impede the incorporation of its features or its service, subject to agreement by the Headquarters of CCS.

1.1.3.2 Any fitting, material, appliance or apparatus, other than that required in CCS Rules, may be allowed to be fitted in a boat, if it is satisfied by trial thereof or otherwise that such fitting, material, appliance or apparatus is at least as effective as that required in the Rules.

1.1.3.3 Equivalence or substitution to those methods of calculation, criteria of evaluation, manufacturing procedures, materials, survey and test requirements specified by the Rules may be accepted subject to agreement by the Headquarters of CCS, when relevant tests, theoretical basis or service experience are provided, or recognized effective standards are available.

1.1.4 Interpretations of the Rules

1.1.4.1 The right of interpretations on the Rules is to be left solely to the Headquarters of the Society.

1.1.4.2 In case of any different understanding to the English version of the Rules, the currently effective Chinese version of the Rules is to prevail.

1.1.5 Statutory surveys

1.1.5.1 CCS will undertake part or entire statutory surveys of boats under the authority of the Government of flag States and in accordance with the application or contracts/agreements from the boat owners or designers or shipyards.

1.1.5.2 For boats intended to be classed with CCS, CCS will carry out the classification survey in conjunction with the statutory survey when so authorized.

1.1.5.3 CCS will issue relevant statutory certificates and/or reports, upon completion of design review, surveys during construction and after construction, and the classification part is confirmed complying with the CCS requirements relating to classification and satisfying the corresponding statutory requirements.

1.1.5.4 For boats which the classification and statutory surveys are carried out by CCS, where the classification certificate is invalid, then the corresponding statutory certificate will be invalid simultaneously.

1.1.5.5 In accordance with the client's request or contracts/agreements, CCS may also undertake related statutory surveys.

1.1.5.6 CCS will issue relevant documents of compliance and/or reports, upon completion of design review, surveys during construction and after construction, and the classification part is confirmed complying with the CCS requirements relating to classification and satisfying the corresponding statutory requirements.

Section 2 Surveys and Certificates

1.2.1 Types of survey

1.2.1.1 The types of survey are divided into:

(1) Initial survey, including:

① construction survey for newbuildings;

② initial survey for existing boats (including those constructed not under the design review and supervision of CCS in accordance with the Rules, however subsequent survey carried out and considered to comply with the provisions of the Rules by CCS).

(2) Surveys after construction, including:

① annual survey;

② up-to-slipway/docking survey;

③ special survey;

④ occasional survey.

1.2.1.2 All surveys mentioned in this Section may be carried out as appropriate basing on each type of boat.

1.2.2 Issue of certificates

1.2.2.1 Where a boat is found in compliance with the relevant provisions of the Rules and other requirements after the initial classification survey, the character of classification and corresponding class notations will be assigned and the classification certificate will be issued.

1.2.2.2 The validity of classification certificates is not to exceed 2 years for passenger boat, 5 years for high speed boat and 5 years for cargo boat.

1.2.3 Interval of surveys after construction

1.2.3.1 The boat having the classification certificate is to be carried out surveys after construction in accordance with the specified interval and the requirements of 1.2.6 to 1.2.8 of this Section.

1.2.3.2 Annual surveys are to be carried out within 3 months before or after each anniversary date of the certificate. After a satisfactory survey, the Surveyor is to endorse the corresponding certificates to confirm the certificates are valid continuously within the specified period.

1.2.3.3 Up-to-slipway/docking surveys are to be carried out once every two years for passenger boat, annually for high speed boat and a minimum of twice within a five-year period for cargo boat, the maximum interval between successive surveys is not to exceed 3 years, however one of the two surveys required in each five-year period is to coincide with the special survey. After a satisfactory survey, the Surveyor is to endorse the corresponding certificates to confirm the certificates are valid continuously within the specified period.

1.2.3.4 The interval of special surveys is not to exceed 2 years for passenger boat, 5 years for high speed boat and 5 years for cargo boat. Corresponding certificate is to be renewed after a satisfactory survey. Where it is not able to complete the special survey by its due date, the boat may be granted an extension not exceeding 3 months subject to agreement.

1.2.3.5 The special survey may be carried out in conjunction with annual survey and docking survey.

1.2.3.6 An occasional survey is to be applied for in either of the following conditions:

(1) an accident to a boat which affects its seaworthiness;

(2) alteration of a boat's intended purpose or service area as restricted in its certificates;

(3) invalidity of a boat's statutory certificate;

(4) changes of a boat's owner or manager, and of a boat's name or port of registry;

(5) repairs or modification involved in the safety of a boat.

After a satisfactory survey, the Surveyor is to endorse the corresponding certificates to confirm the certificates are valid continuously within the specified period.

1.2.3.7 All the certificates will be invalid automatically where the boat is not operated in accordance with the service requirements stipulated by the certificates or is not carried out surveys after construction.

1.2.4 Characters of classification and class notations for classed boats

1.2.4.1 Boats applied for and classed with the Society is to be assigned with the following characters of classification as appropriate after approval:

★ CSAD
<u>★</u> CSAD

Meaning of the characters of classification are to be as follows:

★ — indicating that the boat has been constructed under the design review and supervision of CCS in accordance with the Rules, and comply with the requirements of the Rules;
<u>★</u> — indicating that the boat has not been constructed under the design review and supervision of CCS, however subsequent survey carried out and considered to comply with the provisions of the Rules by CCS;
CSAD — indicating that the boat's structure and equipment comply fully with the requirements of the Rules, and suitable for the service in domestic waters.

1.2.4.2 Boats classed with the Society will be assigned type notations and service restriction notations to be affixed to the character of classification, depending on the specific cases.

(1) Boat type notations are shown in Table 1.2.4.2(1).

(2) Service restriction notations are shown in Table 1.2.4.2(2).

Type notations **Table 1.2.4.2(1)**

Type of boat	Type notation
Passenger boat Cargo boat Non-propulsion boat	Passenger Boat Cargo Boat Non-propulsion Boat

Service restriction notations **Table 1.2.4.2(2)**

Service restriction	Service restriction notation
Coastal service restriction Sheltered water service restriction Calm water service restriction	Coastal Service Restriction Sheltered Water Service Restriction Calm Water Service Restriction

1.2.4.3 High speed boat complying with the Rules is to be affixed HSC to the type notation by the Society.

1.2.4.4 LPG power-driven boats complying with the requirements of Chapter 6 of the Rules will be assigned LPG Power-driven notation by the Society.

1.2.5 Initial survey

1.2.5.1 Before construction of a boat, plans and documents in triplicate as specified in this Section are to be submitted to the Society for approval.

1.2.5.2 The approved plans and documents are only effective in the designated scope of the construction numbers. The validity of the approved plans and documents is 4 years.

1.2.5.3 The following plans and documents are to be submitted to the Society for approval as appropriate:

*(1) General arrangement;

*(2) Construction profile (including main transverse sections, bow and stern construction, bulkheads, decks, superstructure, typical joints, etc.);

(3) Laminate design;

(4) Shell expansion;

(5) Welding methods and specifications

(6) Construction plan of main engine seating and gear box seating;

(7) Technology specifications of hull construction;

*(8) Structure, installation and arrangement of doors, windows and covers;

(9) Calculations of equipment number and arrangement of anchoring, mooring, handrails and deck skid-proof;

(10) Construction of rudder (including rudder blades, rudder stocks, rudder bearings and connections) and Calculations of rudder strength;

*(11) Arrangement of machinery spaces;

*(12) Ventilation arrangement in machinery spaces;

*(13) Shafting arrangement and propeller plan;

(14) Calculations of shafting and propeller strength;

(15) Arrangement of Z-type propelling unit or stern machinery of inboard/outboard engine;

*(16) Steering system;

*(17) Arrangement of piping (including main/auxiliary exhaust piping, fuel oil piping, fire piping and bilge piping);

(18) Electric loading calculations (including calculations of storage battery capacity);

*(19) Electric power system, marking:

① primary rated parameters of motors, transformers, storage batteries and power electric equipment;

② all the feeder lines on switchboard;

③ types, section areas and primary rated parameters of cables;

④ types and primary rated parameters of circuit breakers and fuses.

(20) Single line of switchboard;

*(21) Arrangement of electric power equipment (including installation position of motors, storage batteries, switchboards, etc.);

(22) Schematic diagrams and arrangement of lighting;

*(23) Boat's operation manual (only applicable for high speed boat and yacht, refer to Appendix).

1.2.5.4 The following plans and documents are to be submitted to the Society for information as appropriate:

*(1) General specification;

(2) Lines;

(3) Calculations of weight and gravity center;

(4) Hydrostatic curves;

*(5) Scantling calculations according to the Rules;

(6) Tonnage calculations;

*(7) Thickness calculations of window glass;

*(8) Particulars of all boat equipment.

1.2.5.5 The names of plans and documents to be submitted may not be all the same, however at least the contents of the above-mentioned plans and documents are to be included. In addition to 1.2.5.3 and 1.2.5.4, other plans and documents may be required to submit by the Society according to the practical cases.

1.2.5.6 The plans and documents of the existing boats for initial survey may be in accordance with the requirements marked with * in 1.2.5.3 and 1.2.5.4.

1.2.5.7 Hull surveys of newbuildings are as follows:

(1) to confirm material, technology, equipment and fittings used for hull structure complying with the rules requirements and holding the relevant marine product certificates;

(2) to examine hull forming die;

(3) to check test report of mechanical properties of hull plating specimens (including single plate and sandwich plate);

(4) to check correctness, completeness and welds quality of hull assembly;

(5) to examine after hull if formed;

(6) to examine installation quality of the windows of the first layer of superstructure and the front wall of bridge room (including connections between window glasses, frames and bulkheads and walls);

(7) to examine anchoring and mooring equipment;

(8) inclination test.

1.2.5.8 Machinery surveys and electrical surveys of newbuildings are as follows:

(1) to confirm marine products certificates of essential machinery equipment;

(2) tightness test of piping system after installation onboard;

(3) installation and test of essential machinery;

(4) installation and test of system;

(5) to confirm product certificates of electrical equipment in primary purposes;

(6) to examine and test the generators, storage batteries and switchboards;

(7) specification check and installation survey of cables;

(8) internal communication equipment test;

(9) survey and test of main/auxiliary engines, steering systems and control, safety and alarm systems;

(10) to examine lighting system.

1.2.5.9 Mooring trials and sea trials are to be made in accordance with the requirements for Programme of Mooring and Sea Trials.

1.2.5.10 Initial survey of existing boats

(1) Plans and documents to be submitted for initial survey of existing boats are to be in accordance with the requirements of 1.2.5.6 of this Section.

(2) The initial survey items may be determined depending on the boat's age and actual condition, but to be carried out at least in accordance with the annual survey items. For passenger boats over 5 years of age, surveys are to be carried out in accordance with the renewal survey items.

1.2.6 Annual survey

1.2.6.1 Hull surveys are as follows:

(1) to examine appearance of hull structure and superstructure whether it has cracks or turns to white or laminates for fabric reinforced plastics boat;

(2) to examine shell plating, deck and bulkheads whether they have any corrosion for metal boats;

(3) to examine any evidence of loosing or water leakage in way of connections of the hull;

(4) to examine effectiveness of fore window frame and glass connection for high speed boat;

(5) to examine whether natural vents of petrol internal/external engines are effective;

(6) to examine complement and effectiveness of mooring and rudder equipment.

1.2.6.2 Machinery surveys and electrical surveys are as follows:

(1) an external examination of propelling unit, auxiliary engine in primary purposes. If deemed necessary, an effectiveness test may be conducted for some item;

(2) a general examination of machinery spaces;

(3) to examine remote control system of main engines and hydraulic operating system of Z-type propelling units and to confirm they are in good order;

(4) to examine whether oil tanks and fuel oil system are in good order without leakage;

(5) to examine steering gears and control system and test to be carried out under working conditions;

(6) to examine operating condition of essential piping systems such as bilge system and main engine cooling system, etc.;

(7) internal communications test;

(8) an external examination of generators and storage batteries, and its operation;

(9) a general examination and test of electrical equipment and cables under working conditions as far as practicable;

(10) a general examination of earthing and lightning-rod earthing.

1.2.6.3 Annual survey items for high speed boat are to be same as special survey items.

1.2.7 Up-to slipway/docking survey

1.2.7.1 The up-to-slipway/docking survey items are as follows:

(1) to examine cracks, damages and corrosions of shell under waterline;

(2) to examine integrity of rudders, rudder stocks, rudder bearings, Z-type propelling units, propellers, screw shaft and bearings, water-jet unit, suction boxes, and gratings;

(3) to examine whether the earth plates of shell are in good order.

1.2.8 Special survey

1.2.8.1 In addition to annual survey and up-to-slipway/docking survey items, the special survey items are to include the following:

(1) for motors: to examine cylinders, cylinder heads, valves, pistons, connecting rods, crank shafts and all of the parts, i.e. bearings, engine foundations, chassises, coolers, shock dampers, engine-driven pumps;

(2) for gear boxes: to examine wheels, pinions, shafts, bearings and incorporated clutch arrangements;

(3) for Z-type propelling units: to examine wheels, pinions, shafts, bearings and sealing arrangements;

(4) maneuvering test is to be carried out on propelling working condition for the propulsion machinery, the remote control system and hydraulic operating system of main engines and Z-type propelling units are in good order;

(5) to withdraw screw shaft and examine shafts, liners, keys, shaft cones, fillets of flanges, stern tube bearings, oil sealing arrangement and the fit conditions of propellers and screw shaft cones;

(6) for jet propeller: to examine blades, shafts, shaft seals, guiding nozzles, reverse and control systems in way of ingress-egress shafts and measure clearance between blades and guide ducts;

(7) measurement of insulation resistance for electrical equipment and circuits;

(8) to examine generators, storage batteries and steering motor (if any), and a running test under working conditions;

(9) to examine stand-by motors together with controls for essential equipment, and a running test as far as practicable under working conditions;

(10) to examine switchboards (box), to confirm in good working order.

1.2.8.2 The items in 1.2.8.1(2) to (4) of this Chapter may be replaced by the examination of their maintenance records.

1.2.8.3 The plywood of hull is not to turn to white or laminates without any leakage.

1.2.8.4 For metal boats, thickness measurements on suspect areas of hull plating are to be carried out at the second and subsequent special surveys.

Chapter 2   HULL STRUCTURE

Section 1   Fabric Reinforced Plastics Boats

2.1.1   General requirements

2.1.1.1   This Section applies to boats whose hull structures are of FRP material.

2.1.1.2   The manufacturers of FRP boat are to be subject to approval by the Society and construction quality is to be controlled strictly by the manufacturers.

2.1.1.3   The requirements of this Section are applicable to boats with single plate and sandwich plate structures. For air-cushion vehicles, the structures are to comply with the requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

2.1.1.4   Principle of structural design

(1)   The hull structure is to be so designed that the boat can withstand the maximum external force that may be encountered throughout its whole period of normal operation.

(2)   The hull structure may be designed by direct calculation, however the Structural Calculations are to be approved by the Society.

(3)   The width of flat keel or girth of hood keel is not to be less than 0.1*B* (*B* being the molded breadth), the thickness is not to be less than 1.5 times that of the boat's bottom plating and is kept unchangeable within the whole length of boat.

(4)   Shell side longitudinals of the boat with molded depth less than 0.9 m may not be fitted, however, hard chine hull form may be adopted and hull girder strength is to be checked.

(5)   The bottom floors, side frames and deck transverses are to be arranged in the same transverse section and connected fixedly, special cases are to be subject to plan approval.

(6)   The spacing (*S*) of boat's frames or longitudinals are not to be more than 500 mm. The spacing of plate floors for longitudinally framing boat is not to be more than 4 frame-spaces, and that for transversely framing boat is not to be more than 2 frame-spaces.

(7)   The spacing of keels and spacing between keel and bilge chines or midpoints of bilge circular are not to be more than 2 m.

(8)   The hull longitudinal components are to be kept continuous within the whole length of boat as far as possible.

(9)   The ratio of web height and thickness of hood type sectional structural members is not to exceed 30, and that of the face plate width and thickness is not to exceed 20. The ratio of web height and thickness of T type sectional structural members is not to exceed 20, and that of the face plate width and thickness is not to exceed 10. Other sectional type members are to be specially considered.

(10)   The web height of sloping bottom boat's plate floors may be reduced gradually from longitudinal centerplane to sides, however for boat of more than 6 m in length, the web height in way of 3/8 breadth from longitudinal centerplane is not to be less than 1/2 of that in way of longitudinal centerplane.

(11)   For engine room of single-engine boat or flat bottom boat, the center keelson may be replaced by girder of main engine's foundation or two side keelsons (one at each side). The girder of main engine's foundation or side keelson and center keelson are not to be interrupted in way of any bulkhead and are to extend on the back of the bulkhead with the length not to be less than 2 frame-spaces.

(12) The plate thickness is to be such that is not taken the gel coat and repaired composite or other non-reinforced material into account.

2.1.1.5 Hull girder strength

(1) Hull girder strength is to be checked for high speed boat and fabric reinforced plastics boat of 15 m and over in length and L/D equal to or more than 12.

(2) The midsection at half of boat length (L) is in general to be taken as the checking section during calculation of hull girder strength. The amidship section modulus W of freeboard margin line (decked boat) or side top strake line (open deck boat) is not to be less than:

$$W = f L^2 B_w (C_b + 0.7) \quad \text{cm}^3$$

where: f —- factor, $f = 0.25\ L + 24$;
L —- length of boat, in m;
B_w —- breadth in way of full load waterline, in m;
C_b —- block coefficient under full load waterline.

(3) The moment of inertia (I) to neutral axis amidship section is not to be less than:

$$I = 4.0\ WL \qquad \text{cm}^4$$

where: L —- length of boat, in m;
W —- amidship section modulus calculated in accordance with the requirements of 2.1.1.5(2), in cm^3.

(4) Calculation of amidship section modulus

① All continuous longitudinal members within 0.4 L at amidship may be taken into account in the calculation of midsection modulus, however the sectional areas of openings on them are to be deducted from the midsection area.

② In general, a superstructure having a length greater than 0.2 L but within 0.4 L amidship may be taken into account in the hull girder strength. Where there are large amount openings on the side walls of above-mentioned superstructure and the sum of length of all openings on each side wall exceed half of the superstructure length, the superstructure is not to be considered to make contribution to the hull girder strength.

③ Where a boat adopted sandwich construction as parts of hull's members, the concept of equivalent section modulus (W_e) is to be introduced.

For the longitudinal bending of hull girder, the equivalent section modulus (W_e) of the middle transverse section composed by some of members made of sandwich construction is to be calculated as follows:

$$W_e = \frac{\Sigma E_i I_i}{EY} \qquad \text{cm}^3$$

where: E —- modulus of elasticity of material at the point calculated, in N/mm^2;
Y —- vertical distance from the point calculated to the neutral axis of the mid-boat section in cm;
E_i, I_i —- modulus of elasticity for each member's material composing of the midcraft section, in N/mm^2 and moment of inertia to the neutral axis of the midcraft section for each member, in cm^4, respectively.

(5) For catamarans, the transverse strength and the torsional strength of connecting structure of their twin hull are to be checked in accordance with the relevant requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

(6) Allowable stress for calculation of general strength are to be as follows:

$[\sigma] = 0.30\sigma_{nu}$ for allowable bending stress, where, σ_{nu} is the ultimate bending stress of the laminate, in N/mm^2;

$[\tau] = 0.25\tau_u$, for allowable shearing stress of single skin panel, where τ_u is the ultimate shearing stress of the laminate, in N/mm^2;

$[\tau] = 0.5\tau_{cr}$, for allowable shearing stress of sandwich panel, where τ_{cr} is the critical shearing stress of the skin laminate of the sandwich panel in N/mm^2, τ_{cr} is to be taken from the following formulas, whichever the smaller:

$$\tau_{cr} = 0.3\left(E_f^{45^\circ} E_c G_c\right)^{1/3} \quad \text{N/mm}^2$$

$$\tau_{cr} = 0.4\gamma G_c \quad \text{N/mm}^2$$

where: $E_f^{45^\circ}$— compressing modulus of elasticity for the skin laminate of sandwich panel in 45° direction, in N/mm^2, $E_f^{45^\circ}$ may be taken as 60%, where the skin laminate is biaxial laminate;
E_c — compressing modulus of elasticity of core material, in N/mm^2;
G_c — shearing modulus of elasticity of core material, in N/mm^2;
γ — ratio of the distance between centerlines of opposite skin laminates to the mean thickness of opposite laminates, $6 \leqslant \gamma \leqslant 14$.

2.1.1.6 Main engine's foundations and engine room's framings

(1) The structures of main engine's foundations are to have enough strength and rigidity. Transverse separating plates and transverse bracket plates are to be provided in each frame space for girders of foundations to ensure the effective supporting.

(2) In order to increase the compression and bending rigidity, timbers or aluminum alloy sections may be used as core materials of girder webs, however, the core materials are to be effectively bound with the surface of FRP and the bottom floor of boat.

(3) The frames in engine rooms are to be kept continuous to avoid stress concentration.

(4) In the engine room, plate floors are to be provided in each frame space as the boat's bottom is transversely framed and plate floors are to be provided alternative frame space as the boat's bottom is longitudinally framed. The sectional modulus of plate floors are to be increased 10% of the values stipulated in 2.1.2.4 or 2.1.3.6 of this Chapter, and the plate floors are to be effectively connected with foundation girders.

(5) Web frames are to be provided at sides in way of engine room and they are to be fitted in way of plate floors with spacing not to be more than 4 frame-spaces. The sectional moduli of frames and web frames are to be increased by 10% of the values stipulated in 2.1.2.4 or 2.1.3.6 of this Chapter.

2.1.1.7 Stern transom plating

(1) The thickness of stern transom plating is not to be less than 1.2 times that of shell side plating, the requirements for frames and stiffeners for stern transom plating are the same as those for shell side plating.

(2) The stern transom plating is to be so designed as to ensure that an excessive stress is not produced when bending moment and thrust caused by outboard motor or stern propelling unit are transmitted to hull structure.

(3) In general, the stern transom plating of a boat with the outboard motor or stern propelling unit is to be sandwich plate with core material such as plywood or similar rigid suitable material. The total thickness of the stern transom plating is not to be less than that as required in Table 2.1.1.7(3).

Total thickness of stern transom plating **Table 2.1.1.7(3)**

Power of engine P (kW)	Total thickness of stern transom plating (mm) (outboard motor)	Total thickness of stern transom plating (mm) (stern propelling unit)
$18 \leqslant P < 30$	30	35
$30 \leqslant P < 60$	35	40
$60 \leqslant P < 150$	40	45
$P > 150$	Specially considered as per specific case	Specially considered as per specific case

2.1.1.8 Local strengthening

(1) Plate floors are to be fitted in each frame space for the severe areas of high speed boat subject to wave panting (generally within the range of 0.15 L from 1/3 L of bow), or other measures are to be taken.

(2) The shell plating for penetration of propeller shaft bracket, rudder post and their attachments or the plates at the strong points for anchoring, mooring and towing are to be provided with embedded parts and suitably strengthened.

(3) Openings on the shell plating are to be avoided as far as possible. If it is needed, the opening corners are to be rounded, and compensation is to be made for large openings under certain cases.

(4) Where doors, windows and openings are provided in side walls of superstructures or deckhouses, the corners are to be rounded as far as practicable, and sufficient strengthening is to be made if right angle opening needs to be used.

2.1.1.9 Pillars

(1) For pillars of steel and aluminium alloy, reference may be made to the relevant requirements in Rules for Constructions and Classification of Sea-going High Speed Craft by the Society.

(2) Other materials used for pillars are to be subject to approval of the Society.

2.1.1.10 Effective breadth of attached plates

(1) The required values of section modulus of secondary members stipulated in this Section are the minimum ones for them with their attached plates. The effective breadth of attached plates of members b_e is to be taken as follows:

① Where the attached plates are of a single plate, the lesser of following is to be taken:

$$b_e = s,\ \ b_e = 23t + b_s \qquad \text{mm}$$

② Where the attached plates are of a sandwich plate:

For ineffective core such as cellular plastics, balsa wood, etc., the lesser of following is to be taken:

$$b_e = s,\ \ b_e = 11d \qquad \text{mm}$$

For effective core such as plywood, etc., the lesser of following is to be taken:

$$b_e = s,\ \ b_e = 35d \qquad \text{mm}$$

where: s — stiffener spacing, in mm;
t — thickness of attached plates, in mm;
d — distance between centerlines of opposite skin laminates of attached plate, in mm;
b_s — net breadth of secondary members, in mm.

(2) Where the effective material such as pine or plywood is employed as core of the member, the core affection is to be taken into account in calculating the section modulus. The sectional area of the core is to be reduced by the ratio of its bending modulus of elasticity to the bending modulus of elasticity of the member's laminate.

2.1.1.11 Design of laminated plate

(1) For shell plating and members suitable raw materials and reasonable lay up design are to be chosen in accordance with different purposes.

(2) The thickness change of laminated plate is to be gradual and the breadth of transition region is at least 30 times the thickness difference.

2.1.1.12 Mechanical properties of laminated plate specimen

(1) The mechanical properties of test specimen of FRP are to comply with the requirements of Rules for Welding and Materials by the Society.

(2) The thickness t of each laminated plate of glass fiber is to be taken as follows:

$$t = \frac{W_G}{100\gamma_R G} + \frac{W_G}{1000\gamma_G} - \frac{W_G}{1000\gamma_R} \quad \text{mm}$$

where: W_G — design weight of glass-fiber mat or glass-fiber cloth in a unit Area, in g/m^2;
G — content of glass fiber (weight ratio) of laminated plate, in %;
γ_R — specific gravity of resin after solidification , in g/cm^3;
γ_G — specific gravity of glass-fiber mat or glass-fiber cloth, in g/cm^3.

2.1.1.13 Tightness test of hull

(1) After the completion of hull, main compartments are to be subject to waterhead test or hose test for verifying the strength and/or tightness of the structural members. The test pressure is to be as practicable the pressure due to the maximum head of water which the structural elements might have to sustain in the event of damage to the boat.

(2) During hose test, the water pressure of nozzle is not to be less than 200 kPa, the nozzle is to be placed at a distance of not greater than 1.5 m from the tested object, the inner diameter is not to be less than 12 mm. The moving speed of water-jet is not to be greater than 0.1 m/s.

2.1.2 High Speed Boat

2.1.2.1 Vertical acceleration at gravity center of a boat

(1) The vertical acceleration at gravity center of a boat α_{cg} is to be provided with by the boat owner or the designer, normally an average value of the 1/100 maximum acceleration at gravity center of a boat may be taken. The designer may also make an adjustment itself, however α_{cg} is not to exceed 1.3 g for a passenger boat and 2 g for a yacht. For a public boat, a reasonable value α_{cg} may be selected according to the need of the boat owner or the designer.

(2) The relation among the designed vertical acceleration at gravity center of a boat α_{cg} and significant wave height $H_{1/3}$ specified in its service restriction and its speed V_H corresponding to the wave height is as follows:

$$\alpha_{cg} = \frac{1}{426}\left(\frac{V_E}{\sqrt{L}}\right)^{1.4}\left(\frac{H_{1/3}}{B_{WL}} + 0.07\right)(50-\beta)\left(\frac{L}{B_{WL}} - 2\right)\frac{B_{WL}^{\ 3}}{\Delta} g \quad \text{m/s}^2$$

where: g — acceleration of gravity, $g = 9.81$ m/s^2;

V_H — speed at sea with significant wave height $H_{1/3}$, in kn;

$H_{1/3}$ — significant wave height, in m, $H_{1/3} = 4$ m for coastal water service restriction, $H_{1/3} = 2$ m for sheltered water service restriction and $H_{1/3} = 1$ m for calm water service restriction;

L — length of boat, in m;

B_{WL} — width of waterline, in m, means the maximum moulded width measured along the full load waterline of a boat in rest floatation. For multi-hull boat, it means the sum of maximum moulded widths of each hull at full load waterline;

β — deadrise angle at LCG, in °, β_{max} = 3°, see Fig. 2.1.2.1(2);

△ — full-loaded displacement, in t;

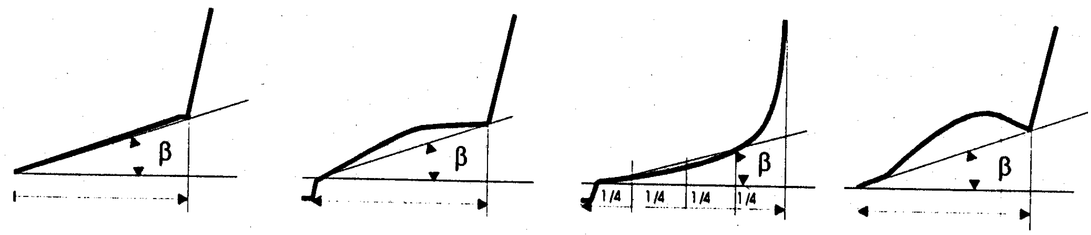

Fig. 2.1.2.1(2)

(3) The final α_{cg} value is to be put in (2) above to calculate group of corresponding values of $H_{1/3}$ to V_H specified in its design service restriction. The values are to be recorded in the boat's operation manual, and to be marked on a label to be fixed and displayed in the bridge room.

2.1.2.2 Local calculated pressure

(1) The wave slamming pressure on bottom P_{sl} is to be calculated by the following formula, and is not to be less than the slamming pressure P_s on side in way of corresponding position as determined by 2.1.2.2(3) of this Section:

$$P_{sl}=1.16K_{l1}\left(\frac{\Delta}{A}\right)^{0.3}a_{cg}d \qquad \text{kN/m}^2$$

where: K_{l1} — longitudinal pressure distribution factor. $K_{l1} = 1$ for forward of amidship, $K_{l1} = 0.5$ for stern, the factor between amidship and stern is to be obtained by linear interpolation;

A — design load area for element considered, in m^2,
for plating, A is not to be taken greater than 2.5 S^2; where S is the spacing of the frames, in m;
for stiffener or girder, A is to be taken as the product: spacing × span;

d — draft, in m;

Δ — full load displacement, in t;

α_{cg} — design vertical acceleration, in m/s^2, to be taken in accordance with that in 2.1.2.1 of this Section.

(2) Deck pressure of connecting structure P_{wd} is to be determined by the following formula, and is not to be less than the pressure on side above the waterline in way of corresponding position as determined by 2.1.2.2(3) of this Section:

$$P_{wd}=0.75K_{l2}\left(\frac{\Delta}{A}\right)^{0.3}a_{cg} \qquad \text{kN/m}^2$$

where: K_{l2} — longitudinal pressure distribution factor. For catamarans, K_{l2} = 1.5 for forward of amidship, K_{l2} = 0.8 for stern; for surface effect craft, K_{l2} = 0.8 for forward of amidship, K_{l2} = 0.5 for stern; for hydrofoil craft, K_{l2} = 0.5. The above factors between amidship and stern is to be obtained by linear interpolation;

Δ, A, α_{cg} — the same as those in (1) above.

(3) Slamming pressure P_s on side is to be taken as:

$$P_s = 9.81h + 0.15P_{sl} \qquad \text{kN/m}^2$$

where: h — vertical distance between the lowest point of side plate and the upper edge of freeboard deck at sides (deck boat) or upper edge of top strake at sides (open boat), in m;
P_{sl} — slamming pressure on bottom in way, in kN/m^2.

(4) Pressure P_d on deck is to be taken as:

$P_d = 0.25L + 4.6$ kN/m^2, for exposed deck;
$P_d = 0.1L + 4.6$ kN/m^2, for unexposed deck;
$P_d = 4.5$ kN/m^2, for passenger accommodation deck.

For boats navigating in sheltered water service restriction and calm water service restriction, the calculated pressure for exposed deck may be taken as 0.9 times and 0.85 times the above value respectively.

(5) Pressure P_h on bulkhead is to be taken as:

$P_h = 10\,h$ kN/m^2, for watertight bulkheads, collision bulkheads and their stiffeners;
$P_h = 10\,h_d + 10$ kN/m^2, for bulkheads and their stiffeners of liquid tanks.

where: h — vertical distance from the bottom edge of plate or midpoint of span of stiffener to the upper deck, in m;
h_d — vertical distance from the bottom edge of plate or midpoint of span of stiffener to the top of the liquid tank, in m.

(6) Pressure P on superstructure and deckhouse is to be taken as:

$P = 5 + 0.3\,L$ kN/m^2, for fore end bulkhead and its stiffeners;
$P = 2.5 + 0.2\,L$ kN/m^2, for side bulkheads, aft end bulkhead and their stiffeners;
$P = 3$ kN/m^2, for top plates and their stiffeners.

where: L — length of boat, in m.

For boats navigating in sheltered water service restriction and calm water service restriction, the calculated pressure for fore bulkheads of superstructure and its stiffeners may be taken as 0.9 times and 0.85 times the above value respectively.

2.1.2.3 Scantling of laminated plates

(1) The minimum thickness $t_{\min}$ of single plate is to be taken as follows:

$$t_{\min} = K_0\sqrt{L} \quad \text{mm}$$

where: K_0 — coefficient, obtained from Table 2.1.2.3(1);
L — length of boat, in m.

Coefficient K_0 **Table 2.1.2.3(1)**

	Bottom, connecting structure	Side	Deck	Superstructure & deckhouse			Bulkhead	
				Front	Side, behind	Top	Watertight	Collision, liquid tank
K_0	1.45	1.25	1.10	1.10	0.95	0.90	1.20	1.30

(2) The thickness t of single plate is not to be less than the following:

$$t = 44.8s\sqrt{\frac{P}{\sigma_{fnu}}} \quad \text{mm}$$

where: σ_{fnu} — ultimate bending stress of laminate, in N/mm^2;

s — frame spacing, in m, in general means the longitudinal spacing, it is the breadth subjected to its area for girders or floors;

P — designed value subjected to positive pressure in member's unit area in the calculation of hull local strength, calculated in accordance with the requirements of 2.1.2.2 of this Section.

(3) The minimum thickness $t_{\min}$ of each skin laminate on structural sandwich plates is to be calculated as follows:

$t_{\min} = K_0\sqrt{L}$ mm, and not less than 2.0 mm for exposed skin laminate ①

$t_{\min} = K_0\sqrt{L} - 0.5$ mm, and not less than 1.5 mm for protected skin laminate ②

where: K_0 — coefficient, obtained from Table 2.1.2.3(3).

Coefficient K_0 **Table 2.1.2.3(3)**

	Bottom, connecting structure	Side	Deck	Superstructure & deckhouse			Bulkhead	
				Front	Side, behind	Top	Watertight	Collision, liquid tank
K_0	0.7	0.6	0.5	0.5	0.4	0.4	0.45	0.55

(4) The total thickness t of a structural sandwich plate is not to be less than:

$$t = \frac{1.428}{K}\left(1 + \frac{1}{\gamma}\right)\frac{Ps}{\tau_c} \quad \text{mm}$$

where: γ — ratio of the distance between centerlines of opposite skin laminates to the mean thickness of opposite skin laminates, $6 \leqslant \gamma \leqslant 14$;

τ_c — ultimate shear stress of sandwich core material, in N/mm^2;

K — coefficient,

$K = 1.86 - 0.06\gamma$ and $K \nless 1$, for core of PU cellular plastic;

$K = 1.95 - 0.079\gamma$ and $K \nless 1$, for core of PVC cellular plastic;

$K = 1$ for core of plywood;

s, P — refer to 2.1.2.3(2) of this Section.

2.1.2.4 Stiffeners and frames

(1) The section modulus W of stiffeners and frames is not to be less than that obtained from the following:

$$W = K\frac{l^2 sP}{\sigma_{fnu}} \quad \text{cm}^3$$

① Exposed skin means the skin laminate subjected to liquid continuously or milling of machine or impacting load.

② Protected skin means the laminate not subjected to the above load.

where: σ_{fnu} — ultimate bending stress of laminate, in N/mm^2;

K — coefficient, obtained from Table 2.1.2.4(1);

l — span of stiffeners and frames, in m, where bracket is provided at the ends of stiffeners and frames, span point may be at half of the bracket length; where no bracket is provided at the ends of stiffeners and frames, span point may be at their ends. For hull stiffeners and frames (e.g. keels, plate floors and girders), the bulkhead connected may be taken as the end point of that stiffeners and frames. For stiffeners and frames of decks and superstructures, (e.g. web beams and girders), in addition to bulkhead, the pillar connected may be taken as the end point of that stiffeners and frames. For spans of stiffeners and frames, refer to 2.1.3.6 of this Section;

s, P — refer to 2.1.2.3(2) of this Section.

Coefficient *K* **Table 2.1.2.4(1)**

	K	
	Keel, girder, web frame, plate floor, web beam	Longitudinals, floor, frame, beam, stiffener
Bottom, connecting structure	480	400
Side	480	400
Deck	480	400
Superstructure	-	400
Watertight bulkhead	-	400
Liquid tank & collision bulkhead	-	480

(2) Where calculation of section modulus for keels as per (1) above is not practicable, such section modulus may be specially considered, but at least the following conditions are to be satisfied simultaneously:

① the section modulus for center keelson is not to be less than 1.5 times the section modulus for plate floor in way; the section modulus for side keelson is not to be less than that for plate floor in way; and

② hull girder strength is to be checked for all boats.

2.1.2.5 The required values of section modulus of secondary members are the minimum ones for them with their attached plates. The effective breadth of attached plates of members b_e is to be taken as follows:

(1) Where the attached plates are of a single plate, the lesser of following is to be taken:

$$b_e = S,\ \ b_e = 23t + b_s \qquad \text{mm}$$

(2) Where the attached plates are of a sandwich plate:

① For ineffective core such as cellular plastics, balsa wood, etc., the lesser of following is to be taken:

$$b_e = S,\ \ b_e = 11d \qquad \text{mm}$$

② For effective core such as plywood, etc., the lesser of following is to be take:

$$b_e = S,\ \ b_e = 35d \qquad \text{mm}$$

where: t — thickness of attached plates, in mm;

d — distance between centerlines of opposite skin laminates of attached plate, in mm;

S — stiffener spacing, in mm;

b_s — net breadth of secondary members, in mm.

2.1.2.6 Where the effective material such as pine or plywood is employed as core of the member, the core affection is to be taken into account in calculating the section modulus. The sectional area of the core is to be reduced by the ratio of its bending modulus of elasticity to the bending modulus of elasticity of the member's laminate.

2.1.2.7 Effective web plate area of girders

(1) The effective web plate area of girders A_e is to be calculated as follows:

$A_e = 0.01\ h_w t_w$ cm², for no bracket at ends of girder

$A_e = 0.01\ h_w t_w + \Delta A_e$ cm², for bracket at ends of girder

where: h_w — effective girder height after deduction of cutouts in the cross section considered, in mm;
t_w — total thickness of FRP web plate, in mm;
ΔA_e — additional shear area for girder with bracket at end, in cm², obtained in accordance with the horizontal angle of the bracket's face plate, refer to Fig. 2.1.2.7(1).
$\Delta A_e = 0.91 f_l$, where $\theta = 45°$,
$\Delta A_e = 0$, where $\theta = 0°$,

The value ΔA_e may be obtained by linear interpolation where $\theta = 0 \sim 45°$, f_l is area of the bracket's face plate in the cross section considered, in cm².

(2) The effective web plate area A_e calculated in accordance with the requirements of 2.1.2.7(1) above is not to be less than $A_{e\,\min}$ as follows:

$$A_{e\,\min} = \frac{25.5 slP}{\tau_c} \quad \text{cm}^2$$

where: τ_c — limited shear stress of sandwich plate, in N/mm²;
s, P, l — refer to 2.1.2.4(1) of this Section.

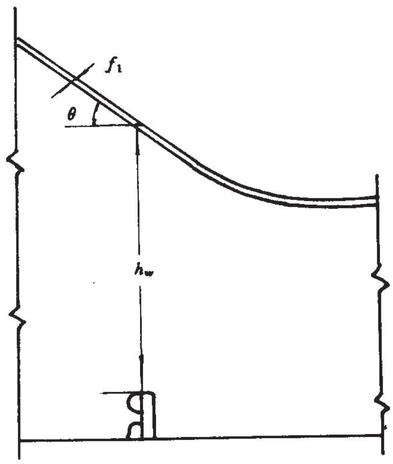

Fig. 2.1.2.7(1)

2.1.3 Non-high speed boat

2.1.3.1 General requirements

(1) The mechanical properties of all laminates designed for boat are not to be less than that as required by Rules for Welding and Materials by the Society. The specified hull structural scantlings are based on the mechanical properties of the standard laminating single skin plate moulded by lay-out with glass fiber biaxial woven rovings.

(2) For other laminating design, where the single skin plate strength is not in conformity with the strength of standard laminating single skin plate, the hull structural scantlings specified may be corrected by multiplying the following coefficient K:

① $K = \sqrt{180/\sigma_{fnu}}$, for thickness correction

where: σ_{fnu} — the ultimate bending stress of the laminate, in N/mm^2.

② $K = 180/\sigma_t$, for section modulus correction, in N/mm^2.

where: σ_t — the ultimate tensile stress of the laminate, in N/mm^2.

③ For laminate with its ultimate bending stress and/or tensile stress more than 400 N/mm^2, in addition to correction, a rigidity of that laminate hull is to be checked.

(3) The minimum thickness t_{min} of laminates is to comply with the relevant requirements of 2.1.2.3 of Section 2.

(4) The bottom plating means the shell plating between flat keel (or keel) and upper corner turning line at bilge.

(5) The web height of center keelsons is not to be less than the height of plate floors and the section modulus is not to be less than 1.5 times that of plate floors in way.

(6) The section modulus of side keelsons is to be equivalent to those of plate floors in way.

(7) The section modulus of center keelsons and side keelsons in engine rooms are to be increased by 10% of the values stipulated in (5) and (6) above respectively.

2.1.3.2 Shell plating

(1) The thickness t of single plate used as bottom plating is not to be less than:

$$t = 13.4 s\sqrt{h} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — vertical distance between the lower edge of the lowest place of bottom plating and the upper edge of freeboard deck at boat's sides, in m.

(2) For boats navigating in calm water service restriction, where the draught is less than 0.35 times moulded depth, the thickness of bottom single plate is to be 0.9 times the values obtained from 2.1.3.2(1) respectively.

(3) The thickness t of single plate used as side plating is not to be less than:

$$t = 12.4 s\sqrt{h} \quad \text{mm}$$

where: s — refer to 2.1.3.2(1), in m;
h — vertical distance between the lowest point of side plate and the upper edge of freeboard deck at boat's sides, in m.

(4) The thickness of single plate used as side plating may be reduced gradually from 0.4 L amidship to fore and aft ends, the thickness at fore and aft ends may be 0.85 times that at amidship.

(5) Where the shell plating is a sandwich plate, the total thickness of sandwich plate t is not to be less than:

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — refer to 2.1.3.2(1) for bottom plating, refer to 2.1.3.2(1) for side plate;
τ_c — shear strength of core material, in N/mm^2.

(6) The thickness of sandwich plate used as shell plating of fore and aft parts (except stern transom plating) is to be same as that at amidship.

2.1.3.3 Deck

(1) The calculated pressure head on deck (h) is obtained from:

h = 0.02 L + 0.46 m , for expose deck
h = 0.01 L + 0.46 m, for non-exposed deck
h =- 0.45 m , for passenger deck

For boats navigating in sheltered water service restriction and calm water service restriction, the calculated pressure head on exposed deck may be taken as 0.9 times and 0.85 times the above value respectively.

(2) The thickness t of single plate used as deck within 0.4 L amidship is not to be less than:

$$t = 16.2\, s\sqrt{h} \quad \text{mm}$$

where: s — spacing of stiffeners and frames, in m;
h — calculated pressure head on deck, in m; obtained in accordance with the relevant height in 2.1.3.3(1) of this Section.

(3) The thickness of single plate used as exposed deck may be reduced gradually from 0.4 L amidship to ends of boat, however, the thickness is not to be less than 0.85 times that of exposed deck at amidship.

(4) Where the deck is a sandwich plate, the total thickness t of deck is not to be less than:

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — calculated pressure head on deck, in m; obtained in accordance with the relevant requirements of 2.1.3.3(1) of this Section;
τ_c — shear strength of core material, in N/mm^2.

2.1.3.4 Bulkhead plating

(1) The thickness t of single plate used as bulkhead plating is not to be less than:

$$t = 12.2\, s\sqrt{h} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — calculated pressure head, in m; vertical distance measured from lower edge of bulkhead plating to tank top.

(2) Where the bulkhead is a sandwich plate, the total thickness t of the plate is not to be less than:

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — calculated pressure head, in m; vertical distance measured from lower edge of bulkhead plating to tank top;
τ_c — shear strength of core material, in N/mm^2.

(3) In calculation of scantling of collision bulkhead, the calculated pressure head h is to be 1.25 times of the corresponding specified height.

2.1.3.5 Wall plating of superstructure and deckhouse

(1) The calculated pressure head h of fore end walls, side walls and aft walls of superstructures or deckhouses are to be as follows:

$h = 0.02L + 0.5$ m, for fore end wall;
$h = 0.02L + 0.25$ m, for side and aft end wall;
$h = 0.3$ m, for top plate.

(2) For boats navigating in sheltered water service restriction and calm water service restriction, the calculated pressure head of fore wall of superstructure or deckhouse may be taken as 0.9 times and 0.85 times above value in (1) respectively.

(3) The thickness t of single plate used as wall plating of superstructure or deckhouse is not to be less than:

$$t = 11.7\, s\sqrt{h} \qquad \text{mm}$$

where: s — length of short side of plate field, in m;
h — calculated pressure head, in m; obtained in accordance with the relevant requirements of (1) above.

(4) Where the wall plating of superstructure or deckhouse is a sandwich plate, the total thickness of sandwich plate is not to be less than:

$$t = \frac{11hs}{\tau_c} \qquad \text{mm}$$

where: s — length of short side of plate field, in m;
h — calculated pressure head on deck, in m; obtained in accordance with the relevant requirements of (1) above;
τ_c — shear strength of core material, in N/mm^2.

2.1.3.6 Framing

(1) Plate floors

① The section modulus W of plate floor is not to be less than:

$$W = 15.4\, sDl^2 \qquad \text{cm}^3$$

where: s — spacing of plate floor, in m;
D — moulded depth, in m;
l — span of plate floor, in m; it is the distance between the surface plate of plate floor and the intersection point of sides; if longitudinal bulkhead is provided, it is the distance between longitudinal bulkhead and sides or the distance between longitudinal bulkheads, whichever is the greater.

② The height H of plate floor in longitudinal centerplane is no to be less than:

$$H = 62.5\, l \qquad \text{mm}$$

where: l — refer to (1) above.

(2) The section modulus W of longitudinals at boat's bottom is not to be less than:

$$W = 25.7\, shl^2 \qquad \text{cm}^3$$

where: s — spacing of longitudinals, in m;
h — calculated pressure head, in m; the vertical distance measured from lower edge of bottom plating to upper edge of freeboard at sides in the midspan of longitudinal;
l — span of longitudinal, in m; the distance between plate floors or the distance between plate floor and bulkhead, whichever is greater.

(3) Frames

① The section modulus W of frames is not to be less than:

$$W = 24\, shl^2 \qquad \text{cm}^3$$

where: s — frame spacing, in m;
l — frame span, in m; for bottom frame, it is the distance between keels or the distance between keel and side, whichever is the greater; for side frame, it is the vertical distance between upper surface of bottom plating and deck;
h — calculated pressure head, in m; for bottom frame, the vertical distance measured from the lower edge of bottom plating to the upper edge of freeboard deck at sides in the midpoint of frame span, for side frame, the vertical distance between the mid point of frame span and the freeboard deck margin line.

② The section modulus W of web frame is not to be less than:

$$W = 22.6\, shl^2 \qquad \text{cm}^3$$

where: s — web frame spacing, in m;
h — calculated pressure head, in m; the distance between the midpoint of web frame span and the freeboard deck margin line;
l — web frame span, in m; molded depth for single bottom boat, molded depth minus double bottom height for double bottom boat.

(4) The Section modulus W of side longitudinal is not to be less than:

$$W = 22.6\, shl^2 \qquad \text{cm}^3$$

where: s — longitudinal spacing, in m;
h — calculated pressure head, in m; the distance between longitudinal and freeboard deck margin line in way of amidship sides;
l — longitudinal span in m; the distance between web frames or the distance between web frame and bulkhead, whichever is the greater.

(5) Deck beam

① The section modulus W of deck beam is not to be less than:

$$W = 19.6\, shl^2 \qquad \text{cm}^3$$

where: s — beam spacing, in m;
h — calculated pressure head of deck, in m; obtained in accordance with the relevant requirements of 2.1.3.3(1) of this Section;
l — beam span, in m; the distance between side and girder (longitudinal bulkhead) or the distance between girders, whichever is the greater.

② The section modulus W of web beam is not to be less than:

$$W = 17.0shl^2 \quad \text{cm}^3$$

where: s — beam spacing, in m;
h — calculated pressure head of deck, in m; obtained in accordance with the relevant requirements of 2.1.3.3(1) of this Section;
l — web beam span, in m; the distance between sides, the distance between side and pillar or the distance between pillars, whichever is the greater.

(6) The section modulus W of deck longitudinal is not to be less than:

$$W = 21.0\, shl^2 \quad \text{cm}^3$$

where: s — longitudinal spacing, in m;
h — calculated pressure head of deck, in m; obtained in accordance with the relevant requirements of 2.1.3.3(1) of this Section;
l — longitudinal span, in m; the distance between web beams or the distance between web beam and bulkhead, whichever is the greater.

(7) Deck girder

① The deck girder and keel are to be arranged in the same plane as far as possible.

② The section modulus W of deck girder is not to be less than:

$$W = 17.1bhl^2 \quad \text{cm}^3$$

where: b — mean breadth of deck area supported by deck girder, in m;
l — girder span, in m; the distance between pillars or the distance between pillar and bulkhead, whichever is the greater;
h — calculated pressure head of deck, in m; obtained in accordance with the relevant requirements of 2.1.3.3(1) of this Section.

③ Where deck girder is subjected to concentrated load, in addition to meeting the requirements of (2) above, W is to be added as follows:

$$W = 0.102\, cPl \quad \text{cm}^3$$

where: p — concentrated load, in kN;
l — girder span, in m, as the same as ② above;
c — coefficient, obtained from Table 2.1.3.6(7) ③; where a is the distance between the action point P and the further fulcrum of girder, in m.

Coefficient *c* **Table 2.1.3.6(7) ③**

a/l	0.94	0.90	0.85	0.80	0.75	0.70	0.60	0.50
c	3.56	8.32	14.06	18.22	21.39	22.77	23.73	24.75

(8) The section modulus W of bulkhead stiffener is not to be less than:

$$W = Kshl^2 \quad \text{cm}^3$$

where: s — stiffener spacing, in m;
l — stiffener span, in m;
h — calculated pressure head, in m; the vertical distance measured from the midpoint of stiffener span to the top of tank;
K — coefficient, obtained in the following cases:

$K = 21.67$ for stiffener with two ends connected with bracket;
$K = 28.87$ for stiffener with one end connected with bracket;
$K = 34.61$ for stiffener with two stiffener scarfing.

(9) Framing of superstructure or deckhouse

① The scantling of framing for superstructure or deckhouse is to comply with the relevant requirements of 2.1.3.6(5) to 2.1.3.6(7).

② The section modulus W of trunk stiffener of superstructure or deckhouse is not to be less than:

$$W = 20.3shl^2 \qquad \text{cm}^3$$

where: s — stiffener spacing, in m;
l — stiffener span, in m, the practical length of stiffener;
h — calculated pressure head, in m; obtained in accordance with the relevant requirements of 2.1.3.5(1) and (2) of this Section.

Section 2 Steel Boats

2.2.1 General requirements

2.2.1.1 This Section applies to boats whose hull structures are of steel material. For air-cushion vehicles, the structures are to comply with the requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

2.2.1.2 Principle of structural design

(1) The hull structure is to be so designed that the boat can withstand the maximum external force that may be encountered throughout its whole period of service life.

(2) The hull structure may be designed by direct calculation, however the Structural Calculations are to be approved by the Society.

(3) The width of flat keel is not to be less than 600 mm, the thickness of that is not to be less than 1.2 mm plus the thickness of bottom plating is kept unchangeable within the whole length of boat.

(4) Longitudinal members of longitudinal framings are to be continuous or equivalently continuous.

(5) Spacing of short side of hull frames is not to be more than 500 mm. For longitudinal framing boats, spacing of plate floors is not to be more than 4 frame-spaces.

(6) The plate floors, web frames and deck transverses are to be arranged in a same section.

(7) Web plates of bottom longitudinal girders taken into account in hull girder strength are to be continuous in way of the transverse watertight bulkheads, or to be equivalently continuous.

(8) The plate floors are to be fitted on each frame in the engine room, additional strengthening is to be provided in way of the thrust bearing.

(9) The plate floors are to be fitted on both ends of a main engine in the engine room.

2.2.1.3 Hull girder strength

(1) Hull girder strength of steel high speed boat is to meet the requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

(2) Allowable stress for calculation of general strength is to be taken as follows:

$[\sigma] = 0.67\sigma_s$ for allowable bending stress;
$[\tau] = 0.38\sigma_s$ for allowable shearing stress

where: σ_s — yield stress of material, in N/mm^2.

2.2.1.4 Local strengthening

(1) Plate floors are to be fitted in each frame space for the severe areas of high speed boat subject to wave panting (generally within the range of 0.15 L from 1/3 L of bow).

(2) The thickness of stern transom plating is not to be less than that of shell side plating, however where propelling unit is fitted on the stern transom plating, the thickness of stern transom plating is not to be less than 1.2 times that of shell side plating. The shell plating for penetration of propeller shaft bracket, rudder post and their attachments or the plates at the strong points for anchoring, mooring and towing are suitably strengthened.

(3) Openings on the shell plating are to be avoided as far as possible. If it is needed, the opening corners are to be rounded, and compensation is to be made for large openings under certain cases.

(4) Where doors, windows and openings are provided in side walls of superstructures or deckhouses, the corners are to be rounded as far as practicable, and sufficient strengthening is to be made if right angle opening needs to be used.

2.2.1.5 Pillars

(1) For pillars of steel and aluminium alloy, reference may be made to the relevant requirements in Rules for Constructions and Classification of Sea-going High Speed Craft by the Society.

(2) Other materials used for pillars are to be subject to approval of the Society.

2.2.1.6 Tightness test of hull

(1) After the completion of hull, tightness test is to be carried out as required by 2.1.1.13 of this Chapter.

(2) Where a hose test is not practicable because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where deemed necessary by means such as a dye penetrant test or an ultrasonic leak test or an equivalent test.

2.2.2 High speed boat

2.2.2.1 The requirements for vertical acceleration at gravity center of a boat are to be same as in 2.1.2.1 of this Chapter.

2.2.2.2 The requirements for local calculated pressure in way of the bottom, side, deck and superstructure are to be same as in 2.1.2.2 of this chapter.

2.2.2.3 Thickness of plating

(1) The minimum thickness t_{min} of plating is to be taken as follows:

$$t_{min} = 1.1K_0\sqrt{L} \quad \text{mm}$$

where: K_0 — coefficient, to be obtained from Table 2.2.2.3(1);
L — length of boat, in m.

The minimum thickness of plate keel for monohull, catamarans and SES is to be increased by 2 mm over the above value.

Coefficient K_0 **Table 2.2.2.3(1)**

Item		K_0	
		MONO, CAT	SES, FOIL
Bottom plating		0.80	0.60
Connecting structure bottom		0.75	0.50
Side plating		0.70	0.45
Deck: exposed/unexposed		0.60/0.40	0.40/0.30
Superstructure	Front	0.60	0.40
	Side, behind	0.45	0.30
	Top	0.30	0.20
Bulkhead		0.50	0.35
Bottom in way of rudder shaft brackets, etc.		1.60	1.20
Main engine foundations		0.90	0.90

(2) Built-up sections of bottom, including engine seating, is to comply with the following requirements:

$$t \geqslant \frac{h}{70}\sqrt{\frac{\sigma_s}{235}} \quad \text{for web}$$

where: t — web thickness, in mm;
h — web depth, in mm;
σ_s — yield stress of material, in N/mm^2.

$$t \geqslant \frac{b}{15}\sqrt{\frac{\sigma_s}{235}} \quad \text{for face plate}$$

where: t — plate thickness, in mm;
b — plate width, in mm;
σ_s — yield stress of material, in N/mm^2.

(3) The thickness t of plating is to be taken not less than that from the following:

$$t = K_1 C_1 C_2 S \sqrt{\frac{P}{\sigma_s}} \quad \text{mm}$$

where: K_1 — coefficient, to be obtained from Table 2.2.2.3(3);
S — spacing of frames, in m, normally for longitudinal frame spacing, and width subjected to the area for girders or floors;
C_1 — reduction factor for curved plates; C_1 = 1-0.5S/r, where: r is radius of curvature, in m;
C_2 — correction factor for aspect ratio of plate field; $C_2 = (1.1\text{-}0.25S/l)^2$, where: l is span of stiffeners and frames, in m. Where no bracket is provided at the ends of stiffeners and frames, span point may be at their ends; where bracket is provided at the ends of stiffeners and frames, span point may be at half of the bracket length;.
P — design pressure, to be taken as required by 2.1.2.2 of this Chapter;
σ_s — yield stress of material, in N/mm^2.

Coefficient K_1 **Table 2.2.2.3(3)**

Item		K_1		
		Within 0.1L from F.P.	Within 0.4L at amidship	Within 0.1L from A.P.
Bottom, connecting structure bottom		21.5	25.0	21.5
Side	Near bottom	21.5	25.0	21.5
	Near neutral axis	20.5	20.5 for longitudinally framing 21.5 for transversely framing	20.5
	Near deck	20.5	25.0	20.5
Deck, including superstructure/ deckhouse top		20.5 for longitudinally framing 21.5 for transversely framing	25.0	20.5 for longitudinally framing 21.5 for transversely framing
Superstructure/deckhouse wall		21.5		
Bulkhead	Collision	21.5		
	Watertight	19.0		
	Liquid tank	21.5		

2.2.2.4 Stiffeners and frames

(1) The section modulus W including attached plating of stiffeners and frames is not to be less than:

$$W = K_2 \frac{\ell^2 SP}{\sigma_S} \quad \text{cm}^3$$

where: K_2 — coefficient, to be obtained from Table 2.2.2.4(1);
ℓ、P、S、σ_S — same as in 2.2.2.3(3) of this Section.

Coefficient K_2 **Table 2.2.2.4(1)**

Item		Secondary members			Primary members
		Longitudinal member	Beam, frames, floors	stiffeners	Girders, web frames, plate floors, web beams
Bottom, connecting structure bottom		136	150		150
Side		128	150		150
Deck, including superstructure/deckhouse top		Deck: 200 Top: 128	150		150
Superstructure/deckhouse front and side walls				150	150
Superstructure/deckhouse rear walls				150	150
Bulkhead	Collision and liquid tank			150	150
	Watertight			110	110

2.2.2.5 Shearing strength for longitudinals and girders

(1) The effective shear area A_e at end of longitudinals is not to be less than A_{emin} obtained from the following formula:

$$A_{emin} = 22.67 \frac{(\ell - S)SP}{\sigma_S} \quad \text{cm}^2$$

The shear area A_e is to be calculated as follows:

$$A_e = 0.01ht \quad \text{cm}^2$$

where: h — web depth of longitudinals, in mm;

t — web thickness of longitudinals, in mm;

ℓ、P、S、σ_S — same as in 2.2.2.3(3) of this Section.

(2) The effective shear area A_e at end of girders is not to be less than A_{emin} obtained from the following formula:

$$A_{e\,min} = 13.5\frac{S\ell P}{\sigma_S} \quad \text{cm}^2$$

The shear area A_e is to be calculated as follows:

$A_e = 0.01h_W t_W$ cm^2, for no brackets at ends of girder;

$A_e = 0.01h_W t_W + \Delta A_e$ cm^2, for brackets at ends of girder

where: h_W — net girder height after deduction of cutouts in the cross section considered, in mm;

t_W — web thickness, in mm;

ℓ、P、S、σ_S — same as in 2.2.2.3(3) of this Section.

ΔA_e — additional shear area at end of girder with bracket, obtained according to the horizontal angle θ of the bracket's face plate, see Fig. 2.1.2.7(1) of this Chapter.

$\Delta A_e = 0.9f_1$ where $\theta = 45°$; $\Delta A_e = 0$ where $\theta = 0°$; ΔA_e may be obtained by linear interpolation where $\theta =$ 0~45°; f_1 is area of the bracket's face plate in the cross section considered, in cm^2.

2.2.3 Non-high speed boat

2.2.3.1 General requirements

(1) The requirements of 2.2.3 are applicable to conventional steel boats with transverse framing.

(2) Scantlings obtained from the requirements of 2.2.3 are required for boats in the coastal service restriction. Scantlings of boats in the sheltered water service and calm water service restrictions may be reduced by calculation in accordance with the following requirements:

① The thickness of shell plating and strength deck may be reduced by 8% of the calculated thickness as specified, but the minimum thickness of the reduced shell plating and strength deck is not to be less than 4 mm for $L \geqslant 10$ m, and that is not to be less than 3.5 mm for $L < 10$ m.

② The section modulus of hull framing may be reduced by 10% of the calculated section modulus as specified, but the thickness of inner bottom plating and bulkhead plateing, and the web thickness of plate floors, keelson, center girder, side girder, etc. may be reduced by 0.5 mm.

③ The thickness of boundary bulkheads, deck plating of superstructures and deckhouses may be reduced by 0.5 mm of the calculated thickness as specified, but the minimum thickness is not to be less than 3.0 mm. The section modulus of framing of superstructures and deckhouses may be reduced by 10%.

(3) Where the requirements for design principle is not in conformity with that for in 2.2.1.2 of this Section, the former is to prevail.

2.2.3.2 Shell Plating

(1) The thickness t of bottom plating is not to be less than that obtained from the following formulae:

$$t = 0.062s\,(L + 170) \quad \text{mm}$$

$$t = 6.5s\sqrt{d} + 1 \quad \text{mm}$$

where: s — frame spacing, in m;
L — length of boat, in m;
d — draft, in m.

(2) The thickness t of the side plating is not to be less than that obtained form the following formulae:

$$t = 0.07s(L + 115) \quad \text{mm}$$

$$t = 6s\sqrt{d} \quad \text{mm}$$

where: s — frame spacing, in m;
L — length of boat, in m;
d — draft, in m.

(3) The thickness t of strength deck is to be less than that obtained from the following formula, and not less than 4 mm:

$$t = 1.05\text{s}\sqrt{L + 75} \quad \text{mm}$$

where: s — beam spacing, in m;
L — length of boat, in m.

(4) The thickness t of the lower deck is not to be less than that obtained from the following formula, and not less than 4 mm:

$$t = 10s \quad \text{mm}$$

where: s — beam spacing, in m.

2.2.3.3 Hull Framing

(1) The height h, thickness t of web plates and sectional area A of face plates of plate floors at center longitudinal section are not to be less than those obtained from the following formulae respectively:

$$h = 42\,(B + d) - 70 \quad \text{mm}$$
$$t = 0.01h + 3 \quad \text{mm}$$
$$A = 4.8d - 3 \quad \text{cm}^2$$

where: B — breadth of boat, in m;
d — draft, in m.

(2) The face plate thickness of the floor is not to be less than that of web plates, and the breadth of face plates is not to be less than 10 times the thickness of face plates, but need not be more than 15 times.

(3) The web plate thickness of floors in engine rooms is not to be less than that of the web plate of center keelson.

(4) The height of center keelson is to be equal to that of the plate floor. The thickness t of web plates and sectional area A of face plates are not to be less than those obtained from the following formulae respectively:

$t = 0.06L + 6.2$ mm, within 0.4 L amidships;
$t = 0.05\,L + 5.5$ mm, within $0.075L$ at ends;
$A = 0.65d + 2$ cm^2

where: L — length of boat, in m.

(5) The center keelson in forepeak may have the same height, thickness and face plate sectional area as that of the floor respectively.

(6) The scantling of side keelsons is to be the same as that of the plate floors in way. In engine room, the web plate thickness of the side keelsons is not to be less than that of the center keelson.

(7) The spacing of the side keelsons is not to be more than 2.5 m.

(8) The standard spacing s_o of frames is to be calculated as follows:

$$s_o = 1.6\,L + 500 \quad \text{mm}$$

where: L — length of boat, in m.

(9) Where the actual spacing of frames is more than 100 mm of the calculated value in (8) above, shell plating and frames are to be specially considered.

(10) The section modulus W of frames is not to be less than that obtained from the following formula:

$$W = Csdl^2 \quad \text{cm}^3$$

where: s — frame spacing, in m;
d — draft, in m;
l — frame span, in m;
C — coefficient

$$C = \frac{2 + \frac{d}{D} \times 0.65}{1.45 - \frac{\sqrt{D}}{l}}$$

where: D is the moulded depth, in m.

(11) Where side stringers are fitted to support the frames, the section modulus of frames calculated in (10) above may be reduced by half.

(12) Web frames are to be fitted in engine room with spacing not more than that of 4 frame-spaces, and are to extend from the inner bottom to upper deck. The section modulus W is not to be less than that obtained from the following formula:

$$W = 5shl^2 \quad \text{cm}^3$$

where: s — spacing of web frames, in m;
l — span of web frames, in m;
h — vertical distance, in m, measured from the mid-point of web frame span to upper deck at side amidships.

(13) The section modulus W of side stringers is not to be less than that obtained form the following formula:

$$W = 7.8bhl^2 \quad \text{cm}^3$$

where: b — supporting breadth of side stringers, in m;
l — span of side stringers, in m;
h — vertical distance in m, measured from the mid-point of side stringer span to upper deck at side amidships.

(14) The moment of inertia I of the side stringers is not to be less than that obtained from the following formula:

$$I = 2.5Wl \quad \text{cm}^4$$

where: W — section modulus of side stringers, in cm^3;
l — span of side stringers, in m.

(15) The height h of the central girder provided for double bottom is not to be less than that obtained from the following formula, and not less than 700 mm:

$$h = 25B + 42d + 300 \quad \text{mm}$$

where: B — breadth of boat, in m;
d — draft, in m.

(16) The thickness of the central girder is to be the same as that of the flat keel in way, but not less than that of plate floors connected.

(17) The thickness of side girders is to be the same as that of the bottom plating in way, but not less than that of plate floors connected.

(18) Within 0.4 L amidships, the thickness t of the inner bottom plating is not to be less than that obtained from the following formula, and not less than 5 mm:

$$t = 0.04\,L + 8\,s \quad \text{mm}$$

where: L — length of boat, in m;
s — spacing of frames, in m.

(19) The thickness of the inner bottom plating in the engine room and fuel oil tanks are not to be less than that of inner bottom plating increased by 1 mm in accordance with (18) above.

(20) The thickness of the inner bottom plating within 0.075 L of the ends may be 0.9 times that obtained from the calculation in (18) above.

2.2.3.4 Deck framing

(1) The design heads h_o of the weather strength deck are not to be less than that obtained from the following formula, and not less than 0.8 m:

$$h_o = 0.025L + 0.45 \quad \text{m}$$

where: L — length of boat, in m.

(2) The design heads h of other decks are to be selected from Table 2.2.3.4(2).

Design heads of decks **Table 2.2.3.4(2)**

Deck position	Design heads of decks h, m
1. Forecastle deck and weather strength deck forward of 0.15 L from F.P.	$1.2h_o$
2. Deck cargo area of weather deck	$P + 0.3$ or h_o, whichever is greater
3. Strength deck of the superstructure and deckhouse area used for accommodation and stacking sundries, platform deck, deck of the first tier deckhouse	$0.8h_o$
4. Each layer of deck above the superstructure deck or the first tier deckhouse	Taking, in turn, $0.6h_o$, $0.4h_o$…, but not less than 0.45 m

Notes: 1. P in Table is the equivalent height (m) of the water head of cargo weight on cargo decks;
2. Design heads h of decks (platforms) of cargo tanks are not to be less than the height (in m) to the top of overflow pipe of the tank top.

(3) The section modulus W of deck beams is not to be less than that obtained from the following formula:

$$W = 3.5C_1shl^2 + C_2Dd \quad \text{cm}^3$$

where: s — spacing of beams, in m;
l — span of beams, in m, but not less than 2 m;
h — design heads of decks, in m, selected from Table 2.2.3.4(2) of this Section;
D — moulded depth, in m;
d — draft, in m;
C_1 — coefficient,
$C_1 = 0.0065L + 0.61$ for weather strength deck;
$C_1 = 1$ for other decks;
C_2 — coefficient,

$C_2 = 0.8$ for strength deck of boat with single deck;
$C_2 = 0.5$ for other decks.

(4) The section modulus W of deck transverses is not to be less than that obtained from the following formula:

$$W = 5shl^2 \quad \text{cm}^3$$

where: s — spacing of deck transverses, in m;
l — span of deck transverse, in m;
h — design heads of deck, in m, selected from Table 2.2.3.4(2) of this Section.

(5) The section modulus W of deck girders is not to be less than that obtained from the following formula:

$$W = 4.75bhl^2 \quad \text{cm}^3$$

where: b — mean breadth, in m, of deck area supported by the deck girders;
l — span of deck girders, in m;
h — design head of deck, in m, selected from Table 2.2.3.4(2) of this Section.

(6) The moment of inertia I of deck girders is not to be less than that obtained from the following formula:

$$I = 2Wl \quad \text{cm}^4$$

where: W — section modulus of deck girders, in cm^3;
l — span of deck girders, in m.

2.2.3.5 Bulkhead

(1) The thickness t of watertight bulkhead plating is not to be less than that obtained from the following formula, and not less than 4.5 mm:

$$t = 4.2s\sqrt{h} \quad \text{mm}$$

where: s — spacing of stiffeners, in m;
h — vertical distance, in m, measured from the lower edge of the plate in a strake to the bulkhead deck at side, but not to be taken as less than 2.5 m.

(2) The thickness t of collision bulkhead plating is not to be less than that obtained from the following formula:

$$t = 4.7s\sqrt{h} \quad \text{mm}$$

where: s, h — see (1) above.

(3) The thickness of plating for the lowest strake of bulkheads is to be increased by 0.5 mm, and be increased by 1.5 mm in way of the bilge well. The thickness of bulkhead plating in way of the stern tube is to be doubled.

(4) The section modulus W of watertight bulkhead stiffeners is not to be less than that obtained from the following formula:

$$W = Cshl^2 \quad \text{cm}^3$$

where: s — spacing of stiffeners, in m;
h — vertical distance, measured from the mid-point of stiffener span to the bulkhead deck at side, in m, but not to be taken as less than 2 m;
l — span of stiffeners, in m, where girders are fitted, it is the distance between the end of stiffener and the girder or between the girders, whichever is the greater;
C — coefficient, to be taken as follows:

$C = 6$ for stiffeners unattached at both ends, or directly attached to unstiffened plating;
$C = 3$ for stiffeners bracketed at ends, stiffeners directly lap-connected to longitudinal members at ends, stiffeners directly connected to deck plating or girder web at ends, provided that on the other side of the deck or girder, an adjacent member is provided with the same section as and in line with the said stiffener.

(5) The section modulus W of collision bulkhead stiffeners is not to be less than that obtained from the following formula:

$$W = 1.25Cshl^2 \quad \text{cm}^3$$

where: s, h, l, C — see (4) above.

2.2.3.6 Superstructures and deckhouses

(1) The standard spacing of deck frames or boundary stiffeners, to which this Section is applicable, is 500 mm.

(2) The thickness t of fore end bulkheads of superstructures is not to be less than that obtained from the following formulae:

$t = 0.025L + 4$ mm, for $L \geqslant 10$m;
$t = 0.025L + 3.5$ mm, for $L < 10$ m

where: L — length of boat, in m.

(3) The thickness of aft end bulkheads of superstructures is to be reduced by 0.5 mm of that obtained from the calculation in (2) above.

(4) The section modulus W of end bulkhead stiffeners of superstructures is not to be less than that obtained from the following formula:

$$W = 3.5shl^2 \quad \text{cm}^3$$

where: s — spacing of stiffeners, in m;
l — span of stiffener, in m, but not to be taken as less than 2 m;
h — design heads, in m, to be selected as follows:
for fore end bulkheads, to be taken as $0.132L\,(d/D)^{2.5}$, but not to be less than $0.008L + 2.5$ m;
for aft end bulkheads, to be taken as $0.045L\,(d/D)^2$, but not to be less than $0.004L + 1.25$ m;
where: L — length of boat, in m;
d/D — the ratio of draft to moulded depth:
0.7 for $d/D < 0.7$;
0.8 for $d/D > 0.8$.

(5) The thickness of side plating of superstructures is to comply with the following requirements:

① The thickness of side plating of bridges is to be equal to that of side plating amidship.

② The thickness t of side plating of forecastle and poop is not to be less than that obtained from the following formulae:

$t = 0.04L + 4$ mm, for $L \geqslant 10$ m;
$t = 0.04L + 3.5$ mm, for $L < 10$ m

where: L — length of boat, in m.

(6) The side framing of superstructures is to comply with the relevant requirements of 2.2.3.3(10) of this Section.

(7) The thickness t of decks of superstructures is not to be less than that obtained from the following formulae:

$t = 0.035L + 4$ mm, for $L \geqslant 10$ m;
$t = 0.035L + 3.5$ mm, for $L < 10$ m

where: L — length of boat, in m.

(8) The deck framing of superstructures is to comply with the relevant requirements of 2.2.3.4 of this Section.

(9) The thickness t of boundary bulkheads of deckhouses is not to be less than that obtained from the following formula:

$$t = 0.025\,L + 3.5 \quad \text{mm}$$

where: L — length of boat, in m.

(10) The section modulus W of the stiffeners of the deckhouse boundary bulkheads is not to be less than that obtained from the following formula:

$$W = 3.5shl^2 \quad \text{cm}^3$$

where: s, l — see 2.2.3.6(4) of this Section;
h — design heads, in m, to be selected as follows:
for fore end bulkheads of deckhouses, to be taken as $0.12L(d/D)^{2.5}$, but not to be less than $0.008L + 2.5$ m;
for side bulkheads and aft end bulkheads of deckhouses, to be taken as $0.045L(d/D)^2$, but not to be less than $0.004L + 1.25$ m;
where: L, d/D are the same as those in 2.2.3.6(4) of this Section.

(11) The thickness t of the deckhouse decks is not to be less than that obtained from the following formula:

$$t = 0.04L + 3 \quad \text{mm}$$

where: L — length of boat, in m.

Section 3 Aluminum Boats

2.3.1 General requirements

2.3.1.1 This Section applies to boats whose hull structures are of aluminum material. For air-cushion vehicles, the structures are to comply with the requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

2.3.1.2 Principle of structural design

(1) The principle of structural design is same as to that of steel boats.

2.3.1.3 Hull girder strength

(1) Hull girder strength of aluminum boats is to meet the relevant requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

(2) Allowable stress for calculation of general strength is to be taken as follows:

$[\sigma] = 0.67\sigma_{sw}$ for allowable bending stress;

$[\tau] = 0.38\sigma_{sw}$ for allowable shearing stress

where: σ_{sw} — yield stress after welding of member's material, in N/mm^2, to be taken as $\sigma_{0.2}$ in the annealed condition of material.

2.3.1.4 Others

The local strengthening, pillar arrangement and hull tightness testing requirements for aluminum boats are same as to that for steel boats.

2.3.2 Vertical acceleration

2.3.2.1 The requirements for vertical acceleration at gravity center of a boat are same as to that for in 2.1.2.1 of this Chapter.

2.3.3 Local calculated pressure

2.3.3.1 The requirements for local calculated pressure of bottom, side, deck and superstructure are same as to that for in 2.1.2.2 of this Chapter.

2.3.4 Plate thickness

2.3.4.1 The minimum thickness t_{min} of plating is to be taken as follows:

$$t_{min} = K_0 \sqrt{L} \quad \text{mm}$$

where: K_0 — coefficient, to be obtained from Table 2.2.2.3(1);
L — length of boat, in m.

The minimum thickness of plate keel for monohull, catamarans and SES is to be increased by 2 mm over the above value.

2.3.4.2 Built-up sections of bottom, including engine seating, is to comply with the following requirements:

$$t \geqslant \frac{h}{50}\sqrt{\frac{\sigma_{sw}}{125}} \quad \text{for web}$$

where: t — web thickness, in mm;
h — web depth, in mm;
σ_{sw} — yield stress after welding of member's material, in N/mm^2, to be taken in the annealed condition of material.

$$t \geqslant \frac{b}{12}\sqrt{\frac{\sigma_{sw}}{125}} \quad \text{for face plate}$$

where: t — plate thickness, in mm;

b — plate width, in mm;

σ_{sw} — yield stress after welding of member's material, in N/mm^2, to be taken in the annealed condition of material.

2.3.4.3 The thickness t of plating is to be taken not less than that from the following:

$$t = K\ C_1 C_2 S\sqrt{\frac{P}{\sigma_{SW}}} \quad \text{mm}$$

where: K_1 — coefficient, to be obtained from Table 2.3.4.3;

S — spacing of frames, in m, normally for longitudinal frame spacing, and width subjected to the area for girders or floors;

C_1 — reduction factor for curved plates; $C_1 = 1\text{-}0.5S/r$, where: r is radius of curvature, in m;

C_2 — correction factor for aspect ratio of plate field. $C_2 = 1.0$ for $S/l < 0.5$, $C_2 = 0.92$ for $S/l = 1.0$, may be obtained by linear interpolation, where: l is span of stiffeners and frames, in m. Where no bracket is provided at the ends of stiffeners and frames, span point may be at their ends; where bracket is provided at the ends of stiffeners and frames, span point may be at half of the bracket length;.

P — design pressure, to be taken as required by 2.1.2.2 of this Chapter;

σ_{sw} — yield stress after welding of material, in N/mm^2. Where the stiffened plates formed by extruding area used and the welded joint of the plates are far away from the edge of the plates, σ_{Sw} in the formula may be taken as the yield stress of material σ_S. Where riveting structure is used, σ_{Sw} is to be taken as $0.9\sigma_S$.

Coefficient *K* **Table 2.3.4.3**

Item		Plating	Secondary members			Primary members
			Longitudinal member	Beam, frames, floors	stiffeners	Girders, web frames, plate floors, web beams
Bottom, connecting structure bottom		25.0	115	135		135
Side		25.8	130	150		150
Deck, including superstructure/deckhouse top		27.8	130	150		150
Superstructure/deckhouse front walls		25.8			170	150
Superstructure/deckhouse side and rear walls		25.8			150	150
Bulkhead	Collision and liquid tank	25.8			130	150
	Watertight	23.4			120	150

2.3.5 Stiffeners and frames

2.3.5.1 The section modulus W including attached plating of stiffeners and frames is not to be less than:

$$W = \mathrm{K}\frac{\ell^2 SP}{\sigma_{SW}} \quad \text{cm}^3$$

where: K — coefficient, to be obtained from Table 2.3.4.3;

ℓ, P, S — same as in 2.3.4.3 of this Section.

σ_{SW} — yield stress after welding of material, in N/mm^2. The following requirements are to be complied with:

(1) the yield stress σ_{SW} after welding is to be taken for all longitudinals except for bulkhead stiffeners;

(2) the yield stress σ_S of the material may be taken as in the above formula for all girders, web frames and web beams, except for bottom and flat bottom above water;

(3) $\sigma_{SW} = 0.9\sigma_S$ for riveting structure.

2.3.5.2 Shearing strength for longitudinals and girders

(1) The requirements for the shearing strength for longitudinals and girders are same as in 2.2.2.5 of this Chapter.

Section 4 Doors, Windows and Covers

2.4.1 General requirements

2.4.1.1 The external doors of superstructures or deckhouses, and the hatches on open decks are to be provided with weathertight closing devices. The structural strength of weathertight doors and hatch covers is to be equivalent to that of adjacent bulkheads.

2.4.1.2 In general, side scuttles are not to be provided in way of sides under freeboard deck. Where it is necessary to provide circular side scuttles, watertight closing device is to be provided to secure watertightness.

2.4.1.3 No door is to be provided on collision bulkhead but watertight man-hole cover with bolts may be allowed. The door in watertight transverse bulkhead is to be of watertight type and is to be kept closed during navigation.

2.4.1.4 The external windows and their frames of superstructure or deckhouse are to be capable of ensuring weathertightness. The connection between window and frame and the connection between frame and wall plating are to be firm and reliable, and capable of sustaining wave slamming as the boat is navigating normally in its service restriction. The structural strength is to be equivalent to that of adjacent structure.

2.4.1.5 The external windows are to be adopted of toughened glass or polycarbonate glass or laminated glass in compliance with the relevant standards accepted by the Society, and the mechanical properties of glass materials are to be submitted to the Society.

2.4.1.6 Minimum tightness requirements for doors, windows and covers

(1) The circular side scuttles provided below freeboard deck are to comply with the tightness requirements for Class I.

(2) In general, the weathertight hatch covers provided above each open deck (including top plate of superstructure) are to comply with the tightness requirements for Class III. The weathertight hatch covers on open deck forward the amidship onboard a boat navigating in coastal service restriction are to comply with the tightness requirements for Class II.

(3) The open weathertight doors and windows provided in vertical plane or vertical plane with slight inclination above the freeboard deck are to comply with the tightness requirements for Class III.

2.4.1.7 For the tightness testing methods, refer to Table 2.4.1.7.

Tightness testing methods for doors, windows and covers Table 2.4.1.7

<table>
<tr><td colspan="2">Tightness class</td><td>I</td><td>II</td><td>III</td></tr>
<tr><td rowspan="3">Pressure test before installation ①</td><td>Water pressure (MPa)</td><td>0.035</td><td>0.014</td><td>---</td></tr>
<tr><td>Time (min)</td><td>3</td><td>3</td><td>---</td></tr>
<tr><td>Qualified standard</td><td colspan="2">Specimen with no leakage or permanent deformation</td><td>---</td></tr>
<tr><td rowspan="2">Hose test after installation</td><td>Conditions of hose test</td><td colspan="3">Continuous hose time for each specimen ⩾ 3 min;
Flow rate of water column ⩾ 10 l /min;
Pressure of hose = 200 kP;
Distance between nozzle and specimen ⩽ 2m;
Water jet to each side of specimen ⩽ 0.05 m</td></tr>
<tr><td>Qualified standard (volume of water ingress after hose test for each specimen)</td><td colspan="2">⩽ 0.05 l</td><td>⩽ 0.5 l</td></tr>
</table>

Note: ① Pressure test is to be carried out in a designated tank.

2.4.2 Requirements for thickness of window glass

2.4.2.1 The thickness t of window glass is not to be less than:

$$t = \frac{b}{31.6}\sqrt{\frac{kcp}{\sigma_b}} \quad \text{mm}$$

where: b — short side length of window opening, in mm;
p — lateral pressure, in kN/mm², to be taken according to 2.1.2.2(6) for high speed boat or 2.1.3.5(1) to (2) for non-high speed boat;
c — coefficient, obtained from Fig. 2.4.2.1;
σ_b — ultimate bending stress of glass, in MPa;
k — safety factor,
k = 4.0, for toughened safe glass;
k = 3.5 for polycarbonate glass.

Each glass is to be of toughened safe glass in case of sandwich glass, the maximum glass layers are to be of three, and the thickness error for any two layers of them is not to be more than 2 mm, the thickness of plastic membranes in between is not to be more than 0.76 mm.

The thickness t of sandwich glass is not to be less than:

$t = t_1 + t_2 = 1.2teq$, for two-layer sandwich glass;
$t = t_1 + t_2 + t_3 = 1.5teq$, for three-layer sandwich glass

where: t_1, t_2, t_3 — thickness of each glass, in mm;
teq — equivalent thickness as calculated from single layer toughened safe glass, in mm.

In addition, the thickness t to be taken is not to be less than the following minimum values t_{min}:
front window glass of superstructure or bridge room:
t_{min} = 4 mm, for toughened safe glass;
t_{min} = 5 mm, for polycarbonate glass;

side window glass of superstructure or deckhouse:
t_{min} = 3 mm, for toughened safe glass;
t_{min} = 4 mm, for polycarbonate glass.

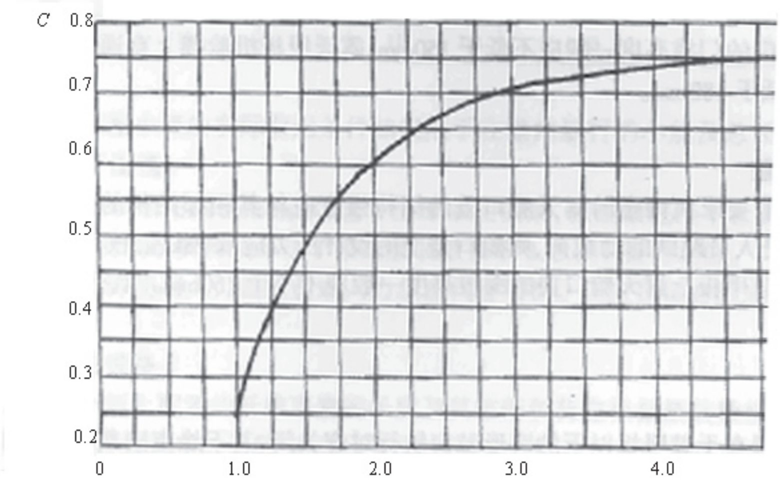

Fig. 2.4.2.1 Window aspect ratio = Long side length/ Short side length

2.4.2.2 Where the window glass is of polycarbonate glass, depth of glass inserted in the frame of window is not to be less than 0.03 times the length of short side of the window glass.

2.4.2.3 The window glass may be connected directly to wall plating by means of adhering. Where necessary, metal horizontal members are to be provided at the lower edge of window glass to support the glass weight. The adhesive adopted is to be capable of resisting ultraviolet light, low and high temperature and chemical cleaning agent. The properties of adhesive such as long-life adhering strength and its working requirements and procedure documents are to be submitted to the Society for approval.

2.4.2.4 In addition, the adhering methods as mentioned in 2.4.2.3 above are to comply with the following requirements:

(1) The adhering width d is not to be less than:

$$d = \frac{2.5 P_W b l}{\sigma_t (b + l)} \quad \text{mm}$$

where: $P_W = 0.0125(50 + 0.5v)^2$ KN/m;
v — maximum speed in calm water, in Kn;
b — short side length of window, in mm;
l — long side length of window, in mm;
σ_t — minimum tensile stress of adhesive, in MPa.

The minimum adhering width is $d_{min} = 20b$ mm.

(2) The thickness t of adhesive is not to be less than:

$t = 5l$ mm, for toughened safe glass;
$t = 8l$ mm, for polycarbonate glass.

The minimum adhering thickness is $t_{min} = 6$ mm.

(3) The tensile stress of adhesive is not to be less than 0.7 MPa, the tensile stress is not to be less than 0.14 MPa when the elongation is 12.5%, and the elongation is to be more than 50% when the adhesive is broken.

2.4.2.5 The opening of rectangular windows is to be of rounded corner type in order to avoid cracks caused by the stresses concentrated in the corners.

Chapter 3 OUTFITTING

Section 1 Rudders

3.1.1 General requirements

3.1.1.1 The requirements of this Section apply to boat with spade rudders or single-plate rudders.

3.1.1.2 The steering gears are to comply with the relevant requirements of Chapter 4.

3.1.1.3 In general, the design of rudder stocks, blades, rudder bearings and the connection between rudder stocks and blades are to comply with the relevant requirements of Rules for Classification of Sea-going Steel Ships by the Society. The rudders for high speed boat may comply with the relevant requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

Section 2 Anchoring and Mooring Equipment

3.2.1 General requirements

3.2.1.1 Unless specified otherwise, all motor boats are to be provided with anchors and chains. The anchors and chains are to be kept connected and to be arranged available for use at any time.

3.2.1.2 Securing of anchors and storage of chains are to be suitably arranged.

3.2.1.3 Effective measures are to be taken in board for securing bower chains.

3.2.2 Equipment number

3.2.2.1 The equipment number N is to be calculated by the following formula:

$$N = \left[\Delta^{2/3} + 2\left(BH_c + \sum S_i \sin\theta_i \right) + 0.1A \right] k$$

where: Δ — full-loaded displacement, in t;

B — breadth of boat, in m, see definition in 1.1.2.1(5);

H_c — vertical distance from full load waterline of a boat in rest floatation to upper deck (for decked boat) or top end of side plate (for open boat), in m;

S_i — projection area of front bulkhead of each tier of deckhouse whose breadth exceeds $B/4$ to section, in m^2;

θ_i — angle between the horizontal level and the front bulkhead of each tier of deckhouse whose breadth exceeds $b/4$, in °;

A — area in profile view of the hull above the full load waterline and the houses whose breadth exceeds $B/4$, in m^2;

k — coefficient, to be taken according to the service restriction:

$k = 1.5$, for coastal service restriction;

$k = 1.0$, for sheltered water service restriction;

$k = 0.70$, for calm water service restriction.

For boat with no deckhouse but windscreen or awning, the projection area of windscreen or awning is to be taken into account for calculation of the equipment number.

3.2.3 Anchoring equipment

3.2.3.1 An anchor with high holding power is normally to be arranged at the bow. The weight of it is not to be less than that obtained from Table 3.2.3.1 based on the equipment number. Where it is not a high holding power anchor, the weight is not to be less than 1.3 times that obtained from Table 3.2.3.1.

Anchoring and mooring equipment **Table 3.2.3.1**

Equipment number		Bow anchor	Diameter of chain		Chain or cable		Fiber ropes for mooring	
Exceeding	Not exceeding	Weight of H.H.P anchor (kg)	AM1 (mm)	AM2 (mm)	Length (m)	Breaking strength (kN)	Length (m)	Breaking strength (kN)
-	5	12	8	8	75	29.4	2×22.5	25
5	10	12	8	8	75	29.4	2×22.5	25
10	15	14	8	8	75	29.4	2×25	25
15	20	20	8	8	80	29.4	2×25	30
20	25	25	8	8	84	29.4	2×25	30
25	30	31	8	8	87	29.4	2×35	30
30	35	37	8	8	90	29.4	2×40	32
35	40	43	8	8	93	29.4	2×40	32
40	50	51	8.5	8	97	29.4	2×40	32
50	70	67	9.5	8.5	105	38.3	3×40	34
70	90	90	11	9.5	113	50.8	3×50	37
90	110	112	12.5	11	121	63.3	3×55	39

3.2.3.2 Where two anchors are provided at the bow, the weight of each anchor is not to be less than 0.7 times that of a single anchor.

3.2.3.3 The anchor may be exempted, subject to agreement of the Society, according to the practical service restriction, e.g. a boat having an overall length less than 8 m and only operating in harbors.

3.2.3.4 The anchor chain and cable may be used, or cable may be used in total length, however, the cable is to be approved by the Society. The overall length and diameter of anchor chain or breaking strength of cable are not to be less than that obtained from Table 3.2.3.1 based on the equipment number.

3.2.3.5 Boats equipped with anchors 30 kg and more in weight are to be provided with anchoring equipment. Hand anchor capstan or hand capstan may be allowed for substituting for windlass, provided that it can effectively handle chain cables.

3.2.4 Mooring equipment

3.2.4.1 The length and breaking strength of fiber ropes for mooring provided onboard are to be obtained from Table 3.2.3.1 based on the equipment number. However, the coefficient k in the formula for calculating the equipment number is: $k = 1$ for coastal service restriction and sheltered water service restriction, $k = 0.85$ for calm water service restriction. The diameter of ropes is not to be less than 15 mm and the overall length is not to be less than 4 times the length of boat. For fiber ropes in the boat having an overall length less than 8 m, special consideration may be given under certain cases subject to agreement of the Society.

3.2.4.2 Suitable number of bitt or cleat is to be fitted respectively on stem, stern and both sides onboard. For boats having an overall length more than 6 m, at least one bitt or cleat is to be fitted respectively on stem or stern.

3.2.4.3 Protective measures, i.e. fender rubber and collision mat are to be provided in both sides onboard in order to prevent hull damage caused by repeated collision between side and wharf when the boat is calling at ports or daily mooring at wharfs.

3.2.4.4 Towed equipment is to be provided and tow ropes to be equipped. The length of tow ropes is to be same as that of anchor chains, with diameter not to be less than 0.85 times that of cables in Table 3.2.3.1.

3.2.4.5 The hull structure in way of the installation places where the equipment (bitt bollard, cleat and towing post) for securing chains, cables, ropes, towing ropes is to be strengthened and capable of bearing the pulling force.

Chapter 4 MACHINERY INSTALLATIONS

Section 1 General Requirements

4.1.1 Application

4.1.1.1 The design, manufacture, installation and testing of main propulsion device, auxiliary machinery, pump and piping system for boats are to comply with the relevant requirements of this Chapter.

4.1.2 Design and installation

4.1.2.1 Design and construction of machinery, fuel oil tanks and associated piping and fittings are to comply with their intended purposes, and are to be so installed and protected as to minimize the hazards to persons when the boat is in normal navigation. Therefore, particular attention is to be paid to moving parts, thermal surfaces and other hazards.

4.1.3 Ambient conditions

4.1.3.1 Main propelling machinery and auxiliary machinery essential to boat's propulsion and safety are to be so designed as to ensure normal operation under the following conditions:

(1) boat's upright; and

(2) static heal not more than 15°; and

(3) static trim not more than 7.5°.

4.1.3.2 In general, the rated power of engine means the maximum continuous power for the engine under the ambient conditions of 0.1 MPa absolute atmosphere, 45℃ ambient temperature, 60% relative humidity and 32℃ sea water temperature.

4.1.4 Means of going astern

4.1.4.1 Suitable power for going astern is to be provided to secure proper control of the boat in all normal circumstances.

4.1.5 Doorways

4.1.5.1 At least one doorway is to be provided in engine room. Stairways are to be provided in doorways of the engine room requiring to be manned and to be easily accessible for operators. An emergency exit is to be additionally provided.

4.1.6 Ventilation

4.1.6.1 Diesel oil engine room is to be adequately ventilated so as to ensure that an adequate supply of air is maintained to the engine room when the engines are operated at full power under any weather conditions for the safety of personnel and normal operation of engines.

4.1.6.2 The ventilation in compartments installed petrol engine and/or petrol tank is to comply with the requirements of Section 3 in this Chapter.

4.1.7 Material

4.1.7.1 The requirements for material of shafting are to comply with the following:

(1) The shafting is to be made of forged or rolled carbon steel, carbon-manganese steel or other material subject to agreement of the Society.

(2) Material test may not be carried out for the shaft having the maximum diameter less than 80 mm, but suitable documents to prove the properties of such material are to be submitted to the Society.

4.1.7.2 Plastic or heat-sensitive material, if used, is to be subject to agreement of the Society.

4.1.7.3 Parts and components, such as side fittings, sea connection, etc. are to be made of steel, bronze or other material approved by the Society.

4.1.8 Control and instrument

4.1.8.1 Passenger boats are to be provided with a control center as far as practicable, so that the personnel can effectively maneuver and control the boat in either normal or emergency condition. In addition, the control center is to be provided at least with instrument having the following indicating (or testing) functions:

(1) power source for maneuver the boat;

(2) main propulsion power;

(3) main fire-extinguishing system, if any;

(4) engine room ventilation;

(5) fuel pump and quick-closing value, if any;

(6) bilge pump and bilge water level.

4.1.9 Products

4.1.9.1 All of the primary machines and equipment onboard, such as engines, gear boxes, elastic couplings, bilge pumps, fire pumps, propellers, Z-type propelling units, water-jet unit, etc. are to have marine product certificates issued by the Society. Other products may be installed onboard only after agreed by the Society.

4.1.10 Testing

4.1.10.1 The mooring trials and sea trials, after completion of installation of machinery, are to be carried out according to the test programmes approved by the Society.

Section 2 Engines

4.2.1 General requirements

4.2.1.1 Each engine driving propelling machinery is to be provided with reliable governors and overspeed protective devices, which are to comply with the following requirements:

(1) Governors are to prevent the engine from exceeding 115% of its rated speed.

(2) Overspeed protective devices are to be independent of governors, and to prevent the engine from exceeding 120% of its rated speed.

4.2.1.2 Each engine driving generators is to be provided with reliable governors and safety devices, which are to comply with the following requirements:

(1) When sudden rated load drops or sudden rated load accelerates, the rate of instantaneous and steady regulating speed is not to be more than 10% and 5% of the rated speed respectively. When sudden rated load accelerates, the steady time (i.e. the time of returning to the range with pulsating rate being ±1%) is not to be more than 5 s.

(2) When rated power of engine is more than 220 kW, overspeed protective devices independent of governors are to be provided to prevent the engine from exceeding 115% of its rated speed.

4.2.1.3 Main engines are to be provided with emergency stopping devices. For main engine remotely controlled in bridge room, the emergency stopping device is to be provided in the bridge room.

4.2.1.4 The total capacity of the starting arrangements is to be sufficient to provide, without replenishment, not less than six consecutive starts of the main engine in cold condition and not less than three consecutive starts of the auxiliary engine in cold condition.

4.2.1.5 The engines are to be so installed inside the boat as to be easily accessible and be maintained and inspected conveniently by operators.

4.2.1.6 The rigid installation of engines inboard is to comply with the following requirements:

(1) The nuts for securing bolts are to be provided with locking devices.

(2) The securing bolts of main engine and gear box are to be provided with at least two fitting bolts respectively.

(3) The main engine and gear box are to use a common foundation as far as practicable.

4.2.1.7 Not less than two sea inlets are to be connected with the cooling water pump of sea-water cooling piping system or circulating system and to be fitted on both sides of boat as far as practicable. For a boat of less than 10 m in length, one sea inlet may be fitted only if the water supply can be ensured.

4.2.2 Alarm device

4.2.2.1 Main engines are to be provided with the following alarm devices:

(1) low-pressure alarm device for lubricating oil;

(2) high-temperature alarm device for cooling water.

For main engine remotely controlled in bridge room, the above alarms are to be provided or extended in the bridge room

4.2.2.2 For prime motor of generator with power more than 35 kW, low-pressure alarm device for lubricating oil is to be provided.

4.2.3 Special requirements for outboard engine

4.2.3.1 The outboard engines are to be reliably fixed on the stern transom plating by through bolts or equivalent means.

4.2.3.2 The installation trunk of outboard engine is to have sufficient dimension so that the outboard engine can be moved around according to the operating conditions.

4.2.3.3 The openings for operational cable and fuel hose of outboard engine are to be effectively sealed if penetrating hull structure.

4.2.3.4 For outboard engine with total power less than 40 kW, the speed and direction can be operated by single handle. For outboard engine with total power of 40 kW and above, handwheel console is to be provided in stem.

4.2.3.5 Where the steering position is open onboard a boat with the speed exceeding 20 kn, a safety rope is to be provided near the steering position. Where the navigating officer falls outside, the safety rope can stop the outboard engine.

Section 3 Petrol Engine and/or Petrol Tank Compartments

4.3.1 Definitions

4.3.1.1 Open compartment means a compartment or space having at least 0.34 m^2 of permanent open area directly exposed to the atmosphere for each cubic meter of net compartment volume.

4.3.2 General requirements

4.3.2.1 Except open compartments, natural ventilation system is to be provided in petrol engine and petrol tank compartments in accordance with the requirements of 4.3.3 of this Section. Powered ventilation system is to be provided in petrol engine compartments in accordance with the requirements of 4.3.4 of this Section.

4.3.2.2 Compartments containing petrol engines and/or petrol tanks are to be separated from the independent passenger's cabins to prevent the petrol gas from entering the passenger's cabins.

4.3.2.3 For compartments containing petrol engines and/or petrol tanks, neither supply nor exhaust ducts are to open into a passenger's cabin.

4.3.2.4 Except open compartments, all electrical components installed in compartments containing petrol engines and/or petrol tanks and in other compartments connecting to such compartments are to be of ignition-protected type.[①]

4.3.2.5 The electrical components installed on the petrol engines are to comply with the relevant requirements of Chapter 5.

4.3.2.6 Portable petrol tank or equipment with petrol fuel is not to be arranged in enclosed spaces, they are to be arranged in a place provided with quick-securing devices and to be ready for jettison in an emergency. The leaked petrol is to be able to be drained directly outboard.

4.3.3 Natural ventilation system

4.3.3.1 A supply opening or duct from the atmosphere and an exhaust opening or duct to the atmosphere are to be provided in natural ventilated compartments. Each exhaust opening or duct is to originate in the lower 1/3 of the compartment. Each supply opening or duct and each exhaust opening or duct in compartment are to be above the normal level of accumulated bilge water.

4.3.3.2 Compartment air intake and exhaust duct openings are to be separated by at least 600 mm with compartment dimension permitting.

4.3.3.3 The combined area of supply openings or ducts, and the combined area of exhaust openings or ducts are to have a minimum internal cross-sectional area calculated as follows, and not less than 3000 mm^2:

$$A = 3300 \ln (V/0.14)$$

where: A — the minimum combined internal cross-sectional area of the openings or ducts, in mm^2;
V — the net compartment volume equal to the total compartment volume minus the volume of permanently installed components in it, in m^3;
ln — natural logarithm.

① Refer to ISO 8846.

4.3.4 Powered ventilation system

4.3.4.1 The total airflow capacity Q of each exhaust blower or combination of blowers in compartment is not to be less than that in Table 4.3.4.1.

Total airflow capacity *Q* **Table 4.3.4.1**

Net volume of compartment (m^3)	Total airflow capacity Q (m^3/min)
< 1	1.5
$1 \leqslant V \leqslant 3$	$1.5 \times V$
> 3	$1.5 \times V + 3$

4.3.4.2 The blower is to be of non-spark type.

4.3.4.3 Each intake duct for an exhaust blower is to be in the lower 1/3 of the compartment and above the normal level of accumulated bilge water.

4.3.4.4 The exhaust outlet of blower is to be as far apart as possible from the outlet of exhaust pipe for engine.

4.3.4.5 The suction blower fitted in the petrol engine compartment is to be operated 4 min before starting of engine. During the service period of boat (including embarkation, disembarkation or laid-up), continuous powered ventilation is to be kept in petrol engine compartment and the blower is not to be stopped. When it stops due to any reasons, visual and audible alarms are to be given in the machinery space and bridge.

Section 4 Shafting and Propulsor

4.4.1 Diameter of shaft

4.4.1.1 The shaft is to be made of forged steel or hot-rolled steel. The tensile strength is to be within the range of 400 to 600 N/mm^2 for manganese steel and carbon steel, and not exceeding 800 N/mm^2 for alloy steel.

4.4.1.2 The diameter of shaft d is not to be less than:

$$d = 100C\sqrt[3]{\frac{P}{n_e}\left(\frac{560}{\sigma_b + 160}\right)} \quad \text{mm}$$

where: C — coefficient, to be taken as follows:

C = 1.0, for intermediate shaft, transmission shaft;

C = 1.22, for screwshaft with keyless propeller shrunk on or attached by means of a flange and pump shaft of water-jet unit;

C = 1.26, for screwshaft carrying a keyed propeller shrunk.

P — rated power transmitted by the shaft, in kW;

n_e — speed of the shaft at P, in r/min;

σ_b — tensile strength of the shaft materials, in N/mm^2. For intermediate and driving shafts, if $\sigma_b >$ 800 N/mm^2, to be taken as 800 N/mm^2; for screwshaft and pump shaft of water-jet unit, if $\sigma_b >$ 600 N/mm^2, to be taken as 600 N/mm^2.

If the shaft material is stainless steel, the shaft diameter d is to be equal to 0.8 times the value obtained from the formula above.

4.4.1.3 Where the shafts have central holes with a diameter $d_o > 0.4\ d_a$, the diameter of the shafts is to be modified by the following formula:

$$d_c = d \sqrt[3]{\frac{1}{1-\left(\frac{d_o}{d_a}\right)^4}} \quad \text{mm}$$

where: d_c — diameter of shaft after modification, in mm;
d — diameter of shaft determined by the formula in 4.4.1.2 of this section, in mm;
d_a — actual diameter of the shaft, in mm.

4.4.2 Shaft liners (if fitted)

4.4.2.1 The thickness t of bronze shaft liners shrunk on screwshafts, in way of bushes, is not to be less than:

$$t = 0.015d + 3.8 \quad \text{mm}$$

where: t — diameter of screwshaft in way of bushes, in mm.

The thickness of a continuous liner between the bushes may be somewhat reduced, but is not to be less than 0.75 t.

4.4.2.2 Continuous liner is generally to be cast in one piece. Where necessary, it may consist of two or more pieces, but these are to be welded by the methods approved by the Society.

4.4.2.3 Where the portion of the shaft between any two lengths of the liner is protected with fiber reinforced plastic or other equivalent materials, the protection at the junction of the liner ends is to be of such a construction as to prevent the shaft from water ingress.

4.4.2.4 Before liner is fitted on the shaft, hydraulic testing with 0.2 MPa pressure is to be made.

4.4.3 Stern tube and bearings

4.4.3.1 The length of sea water lubricated after bearing of stern tube is not to be less than 4 times the stipulated diameter of screwshaft.

4.4.3.2 The length of oil lubricated after bearing of stern tube is not to be less than 2 times the stipulated diameter of screwshaft, and:

(1) an approved oil sealing gland is to be provided;

(2) means for cooling lubrication oil are to be provided.

4.4.3.3 For new types of composed materials approved by the Society, the length of after bearing of stern tube is to be suitably reduced subject to agreement of the Society.

4.4.3.4 Stern tubes are to be subjected to hydraulic testing with a pressure of 0.2 MPa before being fitted onboard.

4.4.4 Coupling

4.4.4.1 For couplings which are transmitted torque by keys, the tensile strength of the key material is not to be less than that of the shaft material, the effective sectional area of the key in shear is to be determined by the following formula:

$$BL \geqslant \frac{d^3}{2.6d_m} \quad \text{mm}^2$$

where: B — breadth of key, in mm;

L — effective length of key, in mm;

d — diameter of intermediate shaft determined by 4.4.1.2, in mm;

d_m — diameter of shaft at mid-length of the key, in mm.

4.4.4.2 The diameter d_f of fitting bolts at the jointing faces of couplings is not to be less than:

$$d_f = 15.92\sqrt{\frac{P \times 10^6}{n_e D Z \sigma_b}} \quad \text{mm}$$

where: P — rated power transmitted by shaft, in kW;

n_e — speed of the shaft at P, in r/min;

Z — number of bolts;

D — diameter of pitch circle of bolts, in mm;

σ_b — tensile strength of bolt material, in N/mm^2. It is not to be less than that of the intermediate shaft material but not greater than 1000 N/mm^2.

4.4.4.3 Where general bolts are used, the diameter d_n at the root of thread of bolts is not to be less than:

$$d_n = 25\sqrt{\frac{P \times 10^6}{n_e D Z \sigma_b}} \quad \text{mm}$$

where: the symbols P, n_e, D, Z, σ_b are same as defined in 4.4.4.2 of this Section.

4.4.5 Propeller

4.4.5.1 The blade thickness of propeller and the installation of propeller to screwshaft are to comply with the relevant requirements of Rules for Construction and Classification of Sea-going High Speed Craft or the standards accepted by the Society.

4.4.6 Z-type propelling unit

4.4.6.1 The diameters of input shaft, vertical spindle and screwshaft for steering and propulsion system are not to be less than those obtained from 4.4.1.2 in this Section.

4.4.6.2 The strength and installation requirements for propeller of such system are to be in compliance with the relevant requirements of 4.4.5 of this Section.

4.4.6.3 The design and manufacture of involute conic gear for transmitting shafting of such system are to comply with the standards accepted by the Society.

4.4.6.4 Such system is to be well lubricated with a temperature of lubricating oil not more than 70℃ .

4.4.6.5 The rotatable steering and propulsion system is to comply with the requirements, i.e. the period of the boat's steering of 180° from full ahead to full astern does not exceed 20 s.

4.4.6.6 Where the power unit of rotatable system is electro-dynamic or electro-hydraulic, stand-by power unit or other emergency operating means are to be provided. Power unit can be exempted if the boat is provided with two or more Z-type propelling units.

4.4.6.7 The hydraulic piping for rotatable system is to comply with the requirements of 4.8.1.7 of Section 8.

4.4.6.8 Rudder indicators for steering and propulsion system are to be provided in bridge room and steering gear room.

4.4.6.9 After completion of manufacture, the parts and components of the system, such as upper gear box, lower gear box and rotatable gear box are to be subject to a hydraulic test at 0.2 MPa and after assembly, they are to be subject to a tightness test at 0.1 MPa.

4.4.6.10 Hydraulic testing is to be carried out for hydraulic piping with 1.5 times the design pressure, after installation onboard, the hydraulic piping together with its accessories are to be subject to a tightness test at 1.25 times the design pressure.

4.4.7 Water-jet unit

4.4.7.1 The water-jet units are to be capable of sustaining loads under all possible working conditions.

4.4.7.2 The diameter of pump shafts of the water-jet units is to comply with the relevant requirements of 4.4.1.2 of this Section.

4.4.7.3 The installation of a water-jet unit, including shafting alignment, is to give safety performance of propulsion system under all working conditions.

4.4.7.4 The pump case of water-jet unit is to be subject to a hydraulic test at 1.5 times the design pressure.

4.4.7.5 Where lubricating oil bearing is used for water-jet unit, the shaft sealing device is to be of approval type in order to prevent water from ingress to oil lubricated parts of the pump.

4.4.7.7 Directional control device for water-jet unit is to be capable of operating in the bridge room.

4.4.7.8 Indicators are to be provided in the bridge room to show speed of water-jet pumps and the water-jet asterning position.

Section 5 Fuel Oil System

4.5.1 General requirements

4.5.1.1 Each part of fuel oil system is to have a sufficient strength and to be so installed as to be capable of bearing impact and vibration which will possibly take place and not to cause any leakage.

4.5.1.2 The material of parts of fuel oil system is to be capable of resisting environment corrosion and temperature affect.

4.5.2 Fuel oil tanks

4.5.2.1 The structure and arrangement of fuel oil tanks are to comply with the following:

(1) The fuel oil tanks are to be tightly fixed on the foundation and certain spaces between fuel oil tanks and bulkheads or other equipment are to be kept as to ensure free ventilation.

(2) Hydraulic pressure testing is to be carried out before fuel oil tank is installed, the test head is to reach 2.4 m above the top of the tank, and leakage is not to be allowed.

(3) The fuel oil tanks are not to be positioned above engines, exhaust pipes and electrical installations, and apart from accumulator batteries, etc. as far as possible.

(4) Vent pipes with sufficient flow area are to be provided for fuel oil tanks and they are led to open spaces where neither flooding nor danger caused by leakage of oil or oil gases. Flame-proof gauze diaphragm is to be provided for opening of vent pipe.

(5) Sounding pipes are to be provided for fuel oil tanks, and the approved liquid level indicator is allowed to substitute for sounding pipe.

(6) The space where fuel oil tank is located is to be effectively ventilated.

(7) Fuel oil tanks are not to be arranged forward of collision bulkheads.

4.5.2.2 The diesel oil tank is to have enough strength and the minimum wall thickness is not to be less than the following:

Austenite chrome nickel steel	1 mm
Low carbon steel subjected to external hot dipping zinc after manufacture	1.5 mm
Aluminum alloy with the content of copper not more than 0.1%	2 mm
Polyethylene	5 mm

For diesel oil tanks made of other materials, the material quality and wall thickness are to be subject to agreement of the Society.

4.5.2.3 The petrol tank is to comply with the following:

(1) The petrol tank is to have sufficient strength and the minimum wall thickness is not to be less than:

Austenite chrome nickel steel	1 mm
Aluminum alloy with the content of copper not more than 0.1%	2 mm

For petrol tanks made of other materials, the material quality and wall thickness are to be subject to agreement of the Society.

(2) No oil draining pipes are allowed to be provided for petrol tanks.

(3) Petrol tanks are to be so arranged as to avoid direct sunlight, and means for prevention of shifting of petrol tank is to be provided.

(4) Filling of petrol tanks is to be carried out by an method approved by the Society.

4.5.3 Fuel oil pipeline

4.5.3.1 The pipeline is to be suitably fastened and protected to prevent from damage and abnormal wearing. Pipeline is not to be combined with the attachment made of different metal material in order to avoid electric erosion.

4.5.3.2 The pipeline is to be made of seamless annealed copper, copper-nickel alloy or other equivalent alloy. For diesel oil, aluminum pipeline may be used.

4.5.3.3 Where hose is used for pipeline, the fire-proof type hose[①] is to be adopted. Non-fireproof hoses[②] may be used for outboard engine.

4.5.3.4 Stop valve is to be provided on the fuel oil pipeline as near as possible to the oil tank. The valve can be closed at an appropriate position outside the engine room.

Section 6 Exhaust System

4.6.1 General requirements

4.6.1.1 Exhaust pipe is to be bound with suitable insulation material, the surface temperature of insulation is not to exceed 60℃ . Means is to be taken to prevent the high temperature surface from injuring persons.

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① Refer to ISO 7840.
② Refer to ISO 8469.

4.6.1.2 If metal hose is fitted on exhaust pipes, the hose is to be of an approved type and capable of bearing its corresponding work temperature.

4..6.1.3 The material of water-cooling exhaust pipes is to be of an anti-corrosion type, otherwise the thickness is to be suitably increased.

4.6.1.4 The exhaust pipes are to be so arranged that the outboard water can not flood into the engine. Anti-back-water device is to be provided for the discharge positioned at less than 300 mm above waterline, and draining cock is to be provided in the lowest place of exhaust pipes where water may easily accumulate.

Section 7 Bilge Pumping System

4.7.1 General requirements

4.7.1.1 Effective bilge pumping system is to be provided in each boat. The system is to be so arranged as to drain water effectively from any watertight compartment other than that intended for permanently storing liquid and prevent water flowing from one compartment to another.

4.7.1.2 For individual compartment, the drainage may be exempted provided that the safety of the boat is not affected by drainage of this compartment through calculation or necessary demonstration.

4.7.1.3 Where deemed necessary, the bilge suction pipes are to be fitted with effective strum boxes for the purpose of protecting bilge water piping. The strum boxes are to be easily removed and replaced for cleaning and the combined area of a box is not to be less than twice the sectional area of the bilge suction pipe.

4.7.1.4 Where deemed necessary, bilge suction valves are to be of non-return type for the purpose of preventing water flowing coracle.

4.7.1.5 When all hatches are closed, bilge pumps, other than portable pumps, are to be capable of being operated for high speed boat.

4.7.1.6 Discharge of bilge water is to satisfy the pollution prevention requirements of the Administration.

4.7.2 Bilge pump

4.7.2.1 In general, the bilge pump is to be of self-priming type.

4.7.2.2 A hand bilge pump is to be provided for a boat of less than or equal to 12 m in length. At least one power bilge pump and one hand bilge pump are to be provided for a motor boat or a non-propulsion boat with auxiliary power of more than 12 m in length. Two hand bilge pumps are recommended to be provided for a non-propulsion boat without auxiliary power of more than 12 m in length. Open deck boat is to be additionally provided with a bailer or a bucket.

4.7.2.3 The bilge pump driven by power may be used for other purposes, but is not to be used as an oil pump.

4.7.2.4 For bilge pump not used to control the flooding quantity at bilge after the boat is damaged, the total displacement of bilge pump is not to be less than the requirements of Table 4.7.2.4.

Total displacement of bilge pump **Table 4.7.2.4**

Length of boat L (m)	Total displacement of bilge pump (m^3/h)
$L \leqslant 6$	0.6
$6 < L \leqslant 12$	1.0
$12 < L \leqslant 24$	2.0

4.7.3 Discharges

4.7.3.1 Screw-down non-return valve is to be fitted in an accessible place for all the discharges draining to the outboard. In general, the said valve may be exempted for the discharge located at a place 350 mm above the waterline and no water flooding will take place due to boat's rolling in navigation.

4.7.4 Bilge water level alarms

4.7.4.1 A watertight compartment fitted with propelling machinery, or any other compartment (except void space) where bilge water may easily accumulate but not be found easily, is to be provided with a bilge alarm of high water level.

4.7.4.2 Any one dry compartment fitted with fixed or portable bilge water suction, where bilge water level is not found easily, are also to be provided with bilge water high level alarms.

4.7.4.3 Visual and audible alarms for bilge water high level are to be provided at the maneuvering position of the boat.

Section 8 Steering Gear

4.8.1 General requirements

4.8.1.1 The steering gear is to ensure the reliable maneuvering for the boat in navigation.

4.8.1.2 Power steering gears are generally to be provided with an emergency steering gear.

4.8.1.3 Where a steering gear comprises two or more power units, the emergency steering gear may be exempted.

4.8.1.4 Emergency steering gear may be exempted for directional control device of outboard engine or internal/external engine.

4.8.1.5 The Z-type propelling unit is to comply with the requirements of 4.4.6 of Section 4 in this Chapter.

4.8.1.6 The water-jet unit with directional control function is to comply with the requirements of 4.4.7 of Section 4 in this Chapter.

4.8.1.7 For hydraulic steering system, the following requirements are also to be complied with:

(1) Material of system components is to be suitable for its working medium.

(2) Oil filter and overflow valve are to be fitted in hydraulic piping system, in general, oil spill is to be back to tanks.

(3) Gas-releasing arrangement is to be provided for hydraulic piping system and hydraulic oil cylinder.

(4) Hoses or pipelines are to avoid heat influence and the hose is to be of an approval type.

(5) Low level alarms are to be provided for the circulating oil box of each hydraulic system and to give visual and audible alarms in machinery spaces and bridge room, however, steering gear for outboard engine may be exceptional.

4.8.1.8 The steering position is to have a good visibility of navigation for the steering persons.

Chapter 5 ELECTRICAL INSTALLATIONS

Section 1 General Requirements

5.1.1 General requirements

5.1.1.1 The design, manufacture, test and installation of main electrical installations onboard are to comply with the relevant requirements of this Chapter, or to meet other corresponding standards accepted by the Society. Electrical equipment and cables are to have appropriate certificates of marine products as required by the Society.

5.1.1.2 Electrical installations onboard are to ensure:

(1) that they are capable of giving power supply to all electrical auxiliary services necessary for maintaining the boat in normal operation;

(2) the safety of passengers, crew and the boat from electrical hazards.

5.1.2 Design, manufacture and installation of electrical equipment

5.1.2.1 Electrical equipment are to be so designed, manufactured and installed as to ensure safe operation and to be easy for inspection and repair.

5.1.2.2 Electrical equipment are to be operated satisfactorily under the voltage and frequency fluctuations as given in Table 5.1.2.2.

Voltage and frequency fluctuation **Table 5.1.2.2**

Equipment	Parameter	Steady-state (%)	Transient	
			%	Maximum recovery time (s)
General equipment	Voltage	+6 to -10	± 20	1.5
	Frequency	± 5	± 10	5
Equipment supplied by accumulator batteries: Connected to batteries during charging Not connected to batteries during charging	Voltage	+ 30 to - 25 + 20 to - 25	—	—

5.1.2.3 All electrical equipment are to be operated satisfactorily under the following environmental conditions:

(1) The ambient air temperatures are as given in Table 5.1.2.3(1).

Ambient air temperatures **Table 5.1.2.3(1)**

Location	Temperature
In enclosed spaces	0℃ to 40℃
In spaces subject to temperatures exceeding 40℃ and below 0℃	According to specific local condition
On open deck	- 25℃ to 40℃

The upper limit of ambient air temperature for the electronic installations is 55℃ .

(2) Moisture, sea air, oil vapour and mould.

(3) Vibration and shock likely to arise under normal service of boat.

(4) The inclination of boat from the normal position is as given in Table 5.1.2.3(4).

Inclination **Table 5.1.2.3(4)**

Equipment components	Angle of inclination			
	Athwartships		Fore-and-aft	
	Static	Dyn	Static	Dyn
Emergency electrical equipment, switchgear, electrical and electronic equipment	22.5	22.5	10	10
Electrical equipment excluding stated above	15	22.5	5	7.5

5.1.2.4 The electrical equipment are to be arranged apart from inflammable material and with effective ventilation and in the places where no inflammable gas may concentrate and where they are not easily subjected to mechanical damage or oil and water corrosion. Where they are fitted in the above mentioned various hazardous places, suitable structural protection or enclosure is to be provided for such equipment.

5.1.2.5 The type of protective casing selected for electrical equipment is to meet the requirements in Table 5.1.2.5.

Protective casing **Table 5.1.2.5**

Location onboard	Grade of protection
Compartments with well protection below deck	IP20
On the tank top sheltered deck	IP22
On the splashed deck	IP44
On the immersed deck	IP56

5.1.3 Earthing

5.1.3.1 Exposed metal parts of electrical equipment and cables which are not intended to be live are to be earthed reliably.

5.1.3.2 Non-metal structure boat is to be provided with an earthing bedplate, which is to be made of copper with not less than 0.1 m^2 in cross sectional area and a thickness not less than 1 mm or other sea water corrosion-resisting metal, such as stainless steel. Where engines or propellers of the non-metal structure boat have an equivalent function of the earthing bedplate, such earthing bedplate is not required.

5.1.3.3 The metal earthing bedplate is to be fixed below the waterline, and is to be immersed in water in any navigation conditions of the boat. For a twin-hull boat, earthing bedplate is to be provided on each hull.

5.1.3.4 The neutral conductor is only to be earthed in way of power source, i.e. the secondary earthing for generator, power transformer onboard. The neutral point of shore power supply is to be earthed by cable of shore power supply and not on the boat.

5.1.3.5 The direct current isopotential lapped conductor (if any) is to be connected to the earth of boat in order to minimize the stray current to the least.

5.1.4 Lightning arresting

5.1.4.1 Lightning rod is to be provided for a boat with non-metal mast and it is to be at least 150 mm higher than the mast. The mast is to have a suitable height in order that lightning rod can function for the boat.

5.1.4.2 Lightning rod is to be made of copper rod with the cross sectional area not less than 8 mm^2 and is to be connected effectively to and in good electrical contact by the metal earthing bedplate as required in 5.1.3.3 and the connecting conductor as required in 5.1.4.3. Special lightning rod is to be provided for the electrical equipment fitted on metal top. For a boat with metal mast, the mast is to be regarded as lightning rod.

5.1.4.3 The connecting conductor is to meet the following requirements:

(1) The connecting conductor is to be a copper conductor with the cross sectional area not less than 8 mm^2.

(2) The cross sectional area of any strand of copper wire is not to be less than 0.71 mm^2 and the insulated copper line is to have at least 19 strands.

(3) The thickness of metal strap or metal strip is to be at least of 1 mm.

Section 2 Source of Electrical Power and Distribution

5.2.1 Type and provision of electrical power source

5.2.1.1 Unless otherwise stated in 5.2.1.5, at least two sources of electrical power are to be provided onboard, in the event of any one electrical power source in failure, the capacity of remainder will still supply those services necessary to provide in normal operational conditions.

5.2.1.2 The sources of electrical power may be either:

(1) generators driven by main independent prime movers;

(2) generators driven by main propulsion engine; or

(3) accumulator batteries.

5.2.1.3 Where the steering gears, various auxiliary machines serving for main propulsion engine and the necessary equipment to ensure the safety navigation of boats are powered by electricity, at least one generating set is to be provided independent from the main engine.

5.2.1.4 For boats navigating without electrical power, main engine shaft driven generator and accumulator batteries may be provided as the source of electrical power. The capacity of shaft driven generator is to supply the power to all the necessary electrical equipment onboard and the capacity of accumulator batteries is at least to be capable of supplying electrical power to the electrical equipment to maintain the safety navigation of boats within a period corresponding to the whole voyage.

5.2.1.5 For boats navigating in sheltered water service restriction or calm water service restriction, two sets of accumulator batteries can be provided as the source of electrical power and the total capacity of two sets of accumulator batteries is to be capable of power supplying for the equipment to maintain the safety navigation of boats.

5.2.1.6 For a non-propulsion boat, source of electrical power may be provided as necessary.

5.2.2 Accumulator batteries

5.2.2.1 For a boat using accumulator batteries as electrical source, if the accumulator batteries have such as reasonable surplus of rated capacity and charging during navigation is not necessary, shore charging device instead of charging device onboard is to be provided. In addition, if the accumulator batteries meet with the requirements for engine starting, they may be used for starting the main engine.

5.2.2.2 Accumulator batteries are to be permanently installed in a dry, ventilated location above the anticipated bilge-water level. Batteries are to be installed in a manner to restrict their movement horizontally and vertically considering the intended use of the boat. A battery, as installed, is not to move more than ±10 mm in any direction when exposed to a force corresponding to twice the battery weight.

5.2.2.3 Accumulator batteries installed onboard are to be capable of inclination of up to 45° without leakage of electrolyte. Means are to be provided for containment of any spilled electrolyte in way of the normal working position of batteries.

5.2.2.4 Accumulator batteries are to be so installed that mechanical damage can be prevented.

5.2.2.5 Accumulator batteries are not to be installed directly above or below a fuel tank or fuel filter.

5.2.2.6 Any metallic component of the fuel system within 300 mm above the battery top, as installed, are to be electrically insulated.

5.2.2.7 Battery cable terminals are not to depend on spring tension for mechanical connection to them.

5.2.2.8 The acid accumulator batteries are to be placed in different enclosed space apart from that for the alkaline accumulator batteries. The switch, fuse and other electrical appliances which are easily to cause electrical arc are not to be fitted in the space where accumulator batteries are placed.

5.2.2.9 The installation position of accumulator batteries is to be separated from the boat's shell with a certain distance.

5.2.2.10 Batteries connected to a charging device having a power① greater than 2 kW are to be installed in a room assigned to the batteries only, or may be located in a box or a locker if the batteries are installed on exposed decks.

5.2.2.11 The quantity of air removed Q of the gas-permeability battery rooms, boxes or lockers is not to be less than:

$$Q = 0.11\, In \qquad \text{m}^3\text{/h}$$

where: I — the maximum charging current during the production of gas, but not less than 25% of the maximum charging current output by the charger, in A;
n — number of battery cells.

5.2.2.12 The quantity of air removed of the valve-regulated sealed battery rooms, boxes or lockers may be reduced to 25% of that required in 5.2.2.11.

5.2.3 Distribution system

5.2.3.1 Where the maximum voltage of distribution system does not exceed 500 V, the following distribution systems may be used:

(1) D.C.
two wire insulated system
two wire system with negative pole earthed

(2) A.C.
single phase two wire insulated system
single phase two wire system with one pole earthed
three phase three wire insulated system
three phase four wire system with neutral point earthed
three phase four wire insulated system

5.2.4 Switchboards (boxes)

5.2.4.1 The switchboards (boxes) are to be installed in a dry, readily accessible and well-ventilated position. The front side of switchboards (boxes), i.e. the operation panel of switches and fuses is to be readily accessible and the back side of switchboard, i.e. the place for connecting lines of terminals is to be accessible.

5.2.4.2 Boats equipped with both D.C. and A.C. electrical systems are to have their distribution from either separate panel boards or from a common one with a partition or other positive means provided clearly to separate the A.C. and D.C. sections from each other, and be clearly identified. Wiring diagrams to identify circuits, components and conductors are to be included with the boat.

① The charging power means the nominal voltage of accumulator batteries multiples the value of maximum charging current.

5.2.4.3 Skid-proof and oil-resisting insulated carpet or insulated wood granting are to be provided in the front of and behind the switchboard (box), with the exception for the voltage less than 50 V.

5.2.5 Sockets

5.2.5.1 Sockets and matching plugs used on A.C. systems are not to be interchangeable with those used in the D.C. systems onboard.

5.2.5.2 Sockets installed in locations subject to rain, spray or splash are to be able to en enclosed in IP55 enclosures as a minimum, when not in use. Sockets mated with the appropriate plug are to be also remained sealed.

5.2.5.3 Sockets installed in areas subject to flooding or momentary submersion are to be in IP56 enclosures as a minimum, also meeting these requirements when in use with electrical plugs.

5.2.5.4 Sockets provided for the galley area are to be located so that appliance cords may be plugged in without crossing above a galley stove or sink or across a traffic area.

Section 3 Protection

5.3.1 Protection

5.3.1.1 Electrical installations are to be protected against accidental over-current, including short-circuit by appropriate devices.

5.3.1.2 Each independent circuit is to be provided with a reliable short-circuit current and overload protective device.

5.3.1.3 Generators are to be protected by means of circuit breakers, for a generator with the power of less than 50 kW, a multi-pole switch and fuse may be used for protection.

5.3.1.4 Over-current protection devices for motor loads are to have a predetermined value of current flow consistent with demand load characteristics of the protected circuit.

5.3.1.5 The rating of the over-current protection device is not to exceed the maximum current-carrying capacity of the conductor being protected.

5.3.1.6 For power transformer, including a bank of two or three single-phase transformers operating as a unit. Each transformer is to be protected by an individual over-current device on the primary side, rated at not more than 125% of the rated primary current of the transformer.

5.3.1.7 The rated or corresponding setting value of the overload protection appliance for each circuit are to be permanently indicated at the location of the protection appliance.

5.3.1.8 Accumulator batteries, other than engine starting batteries, are to be protected against short-circuit with electrical appliances positioned as near as possible to the accumulator batteries.

5.3.1.9 A section switch for accumulator battery is to be provided in a certain accessible position of accumulator batteries as near as practicable, i.e. in way of positive of power supplying system, with exception of:

(1) boats only having outboard motor starting and navigation light circuit;

(2) electronic equipment having protective storage and protecting devices, i.e. bilge pump and alarm, if breakers or fuses are to be protected independently in way of the connecting line terminals of battery as near as possible;

(3) ventilator of fuel oil tank for motor, if fuses are provided independently in way of the electrical source.

5.3.2 Power equipment

5.3.2.1 Motors rated at 1 kW or above and motors required for essential services are to be supplied from distribution boards by separate final sub-circuits.

5.3.2.2 Every electrical motor is to be provided with efficient means of starting and stopping which are, in general, placed near the motor concerned.

5.3.3 Aluminum boats

5.3.3.1 Distribution systems are to be insulated with hull or provided with cathodic protection system.

5.3.3.2 For D.C. system, accumulator batteries are not to be earthed through propelling machinery or associated machinery components. The starting accumulator batteries of engine may be earthed through the engine.

Section 4 Lighting

5.4.1 Lighting

5.4.1.1 Lighting is to be provided for decks and for those parts normally accessible to and used by passengers and crew onboard.

5.4.1.2 In addition to main lighting, emergency lighting is to be provided for spaces where passengers and crew are normally accessible. The emergency lighting is to be supplied from accumulator batteries. For a boat using two sets of accumulator batteries as electrical source, emergency lighting is not necessary.

5.4.1.3 For boats of coastal service restriction, a period of time of emergency lighting is 6 h; for boats of sheltered water service restriction or of calm water service restriction, a period of time of emergency power supply is 3 h.

5.4.1.4 The emergency lighting is to be automatically operable in case the main lighting fails.

Section 5 Cables

5.5.1 General requirements

5.5.1.1 Marine flame retarding cables or wires are to be used onboard. Cables or wires selected are to be determined according to the environmental conditions of the location, laying methods, rated current, duty, diversity factor, permissible voltage drop, etc.

5.5.1.2 Conductor insulation temperature rating of cables or wires in engine room is to be oil-resistant at 70℃ minimum, or protected by insulating conduit or sleeving, and the current-carrying capacity is to be reduced to 0.75 times of the rated capacity.

5.5.1.3 The insulation temperature rating of cables or wires outside the engine room is to be at least 60℃ .

5.5.2 Cable runs

5.5.2.1 Cables or wire runs are to be straight and accessible for inspection and repair as far as possible.

5.5.2.2 Conductors that are not sheathed are to be supported throughout their length in conduits, cable trunking, or trays or by individual supports at maximum intervals of 250 mm.

5.5.2.3 Sheathed conductors and battery conductors to the battery disconnect switch are to be supported at maximum intervals of 450 mm, with the first support not more than 1 m from the terminal. Sheathed outboard-motor starter conductors constitute an exception.

5.5.2.4 Each conductor longer than 200 mm installed separately is to have an area of at least 1 mm^2. Each conductor in a multi-conductor sheath is to have an area of at least 0.75 mm^2 and may extend out of the sheath a distance not to exceeding 800 mm.

5.5.2.5 Each electrical conductor that is part of the electrical system is to have a means to identify its function in the system, except for conductors integral with engines as supplied by their manufacturers.

5.5.2.6 Conductor connections are to be in locations protected from the weather or in IP55 enclosures as a minimum.

5.5.2.7 Current-carrying conductors are to be routed above foreseeable levels of bilge water and other areas where water may accumulate. If conductors must be routed in the bilge area, suitable water-proof means are to be taken.

5.5.2.8 Metals used for terminal studs, nuts and washers are to be corrosion-resistant and galvanically compatible with the conductor and terminal. Aluminum and unplated steel are not to be used for studs, nuts or washer in electrical circuits.

5.5.2.9 All conductors are to have suitable terminals installed, i.e. no bare wires to stud connections unless end strands are made rigid by soldering over the length of their contact with the terminal post connection. Soldered connections are not to be used for connecting or terminating any conductor of nominal cross-sectional area greater than 2.5 mm^2.

5.5.2.10 Twist-on connectors (wire nuts) are not to be used.

5.5.2.11 Exposed shanks of terminals are to be protected against accidental shorting by insulating barriers or sleeves, except those in the protective conductor system.

5.5.2.12 Conductors are to be routed away from exhaust pipes and other heat sources which can damage the insulation. The minimum clearance is 50 mm from water-cooled exhaust components and 250 mm from dry exhaust components, unless an equivalent thermal barrier is provided.

5.5.2.13 Conductors which may be exposed to physical damage are to be protected by sheaths, conduits or other equivalent means. Conductors passing through bulkheads or structural members are to be protected against insulation damage by chafing.

5.5.2.14 No more than four conductors is to be secured to one terminal stud. Cable or wire runs are not to be in the laminating plate in FRP.

Section 6 Additional Requirements for Inboard-mounted Petrol Engine

5.6.1 General requirements

5.6.1.1 Engine-mounted electrical system components which, as designed and installed, can create an electrical arc externally or internally which is capable of igniting a petrol and air mixture, such as circuit breakers, switches, solenoids, alternators, generators, voltage regulators and electric motors, are to be ignition-protected in accordance with the standards[①] accepted by the Society.

5.6.2 Engine electrical systems and components

① Refer to ISO8846.

5.6.2.1 All electrical system components are to be mounted as high as practical on the engine. The engine-cranking motor and ignition distributor position may be as controlled by the basic engine manufacturer's design.

5.6.2.2 Ignition coils and magnetos are to be mounted or protected so that water will not accumulate around the high voltage cap.

5.6.2.3 If an electrical component is required to be ignition-protected and bands or other covers form part of the ignition-protection enclosure, a permanent warning tag is to be affixed to the component, or the band or cover is to be permanently and visibly marked, with appropriate language or symbols, indicating that the band or cover must be in place when the engine is operating.

5.6.2.4 Ignition distributors are to comply with the following requirements:

(1) The distributor, when operating during engine cranking and operation is to be of strength to resist lifting of the cap off the sealing surface in the event of an internal explosion of fuel and air vapour mixture. During test, high-tension (secondary) ignition wiring is to be in place on all distributor cap towers with terminal covering boots as installed during engine operation.

(2) All inlets or outlets are to be covered by effective flame-arrester screens or are to be of a size and length providing equivalent ignition-protection capability.

(3) Terminal covering boots are to be a close fitting to effect a water-tight seal on the outside of high-tension wire insulation and on the outside of the distributor cap tower when in place and meeting the requirements of 5.6.2.5(1).

5.6.2.5 The high-tension (secondary) ignition cable assemblies are to comply with the following requirements:

(1) The high-tension ignition cable assemblies are to have boots and nipples installed which form a water-tight seal with the outside of the high-tension wire insulation, the outside of the distributor cap terminal towers and the outside of the spark-plug ceramic insulator, such that leakage of electrical current will not occur when the connection is submerged for 2 h at 3 cm to 5 cm below the surface of a grounded 3% salt and water solution by weight, with an applied voltage of 20 kV peak (14 kV rms) 50 Hz to 60 Hz applied to the conductor. The voltage is to be applied at a rate of 500 V peak (355 V rms) per second between the free end of the high-tension lead and the grounded salt water solution.

(2) Boots and nipples installed on high-tension ignition cables are to meet the dielectric leakage test requirements of (1) after conditioning at 125℃ ±2℃ for 40 h and subsequent flexing by installation and removal, at room temperature, 10 times on the spark plug and distributor cap tower.

(3) Boots and nipples installed on high-tension ignition cables are to meet the dielectric leakage test requirements of (1) after conditioning for 30 h in a sealed glass container at room temperature when suspended 25 mm±5 mm above test liquid C in accordance with ISO 1817, and subsequent flexing by installation and removal 10 times from the spark plug and distributor cap tower.

(4) Boots and nipples installed on high-tension ignition cables are to meet the dielectric leakage test requirements of (1) after conditioning for 40 h in test oil No.3 in accordance with ISO 1817 maintained at 125℃ ±2℃ .
Remove from oil; cool to room temperature; remove excess oil. Flex boots and nipples by installing and removing 10 times from the spark plug and distributor cap tower.

(5) Tests as per (2) to (4) above are to be conducted on separate groups of high-tension ignition cable assemblies.

Chapter 6 ADDITIONAL REQUIREMENTS FOR LPG POWER-DRIVEN BOATS

Section 1 General Requirements

6.1.1 General requirements

6.1.1.1 This Chapter applies to boats with LPG engine as their main power.

6.1.1.2 For boats applicable to this Chapter, the use of dual fuel is prohibited.

6.1.1.3 Special requirements for outboard LPG engines may be referred to in Chapter 3 of the Rules.

6.1.2 Definitions

6.1.2.1 For the purpose of this Chapter, the relevant definitions are as follows:

(1) LPG means mixture of light hydrocarbon which is in a gaseous state under normal temperature and atmospheric pressure and may be kept in a liquid state by pressurization and cool-down, the basic composed are propane, propylene, butane and butylenes. It may also be composed of commercial butane or commercial propane or the mixture of both.

(2) Gas tank means a special steel cylinder for storage of LPG.

(3) Gas tank space means a fixed space for storage of gas tanks.

(4) Enclosed space means a space enclosed by bulkheads and decks but may have windows and doors.

(5) Semi-enclosed space means a space having structures such as top plating, deck so that its natural ventilation condition is different from that on open deck and it is so arranged that gases can not diffuse.

(6) Open space means an open deck space.

6.1.3 Notations

6.1.3.1 For the classed boats installed with LPG power, the notation LPG will be inserted between characters of classification and class notation.

6.1.4 Initial Survey

6.1.4.1 The following plans and documents are to be submitted to the Society for approval:

(1) Arrangement of LPG machinery space and gas tank space;

(2) LPG supply system;

(3) Ventilation of LPG machinery space and gas tank space;

(4) LPG detection and alarm system;

(5) Operation Manual of LPG Power System.

6.1.4.2 The required plans and documents for initial survey of existing boats may be reduced to submit to the Society for approval in accordance with the boat's conditions.

6.1.4.3 The following items for construction survey of newbuildings are required in addition:

(1) installation and test of LPG engine;

(2) installation and test of LPG supply system;

(3) installation and test of ventilation system in LPG machinery space and gas tank space;

(4) installation and test of LPG remote-control closing devices;

(5) examination of installation position and number of LPG probes and test of LPG detection and alarm system;

(6) confirmation and safety inspection of explosion-proof equipment or ignition-protection equipment.

6.1.4.4 The items of initial survey for existing boats may be reduced in accordance with the boat's conditions, but special attention is to be made to the relevant items of LPG power system, ventilation and fire protection.

6.1.5 Survey for Boats in Service

6.1.5.1 The following items for annual survey are required in addition:

(1) overall examination of LPG machinery space and gas tank space to confirm that no fire and explosion risks exist in the spaces and the ventilation system is in a good working condition;

(2) to examine remote-control system of LPG main engine and confirm that it is in a good working condition;

(3) to examine LPG supply system, where substantial corrosion or leakage of the pipelines and valves is found, repair is made in time;

(4) to examine working conditions of LPG detection and alarm system;

(5) to test the mechanism which remotely closes the LPG supply manifold valve;

(6) to examine working conditions of explosion-proof or ignition-proof electrical equipment;

(7) to examine the bottom plating of gas tank space and engine room and the bulkheads required tightness to ascertain whether their tightness is good.

6.1.5.2 The following items for special survey are required in addition:

(1) to dismantle LPG engine and examine the cylinder, piston, connecting rod, crankshaft, bearing, etc.;

(2) maneuvering test under working conditions of LPG main engine and the remote-control system of main engine is in a good working condition.

Section 2 LPG Engine

6.2.1 General requirements

6.2.1.1 The design and manufacture of LPG engine (hereinafter called the engine) are to comply with the relevant requirements of GB.

6.2.1.2 Where the engine is used as a main engine, reliable governors are to be provided to prevent the engine from exceeding 115% of its rated speed. Governors are to be provided for prime motors where used as generators and their performances are to be in compliance with the relevant requirements of Chapter 4 of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

6.2.1.3 Engines are to be provided with emergency shut-down devices which may cut-off the fuel manifold on LPG supply main and it may be remotely controlled in the bridge room.

6.2.1.4 Heating installation is to be provided in cooling water system of engine in order to ensure that the engine can be normally started in winter.

6.2.1.5 The exhaust piping of engine is to comply with the following requirements:

(1) Suitable insulation is to be used for exhaust pipe to prevent the surface temperature from exceeding 220℃ .

(2) Spark arrester or equivalent means is to be provided in the outlet of exhaust pipe which is as far as possible apart from those for ventilation of engine room and gas tank space.

Section 3 LPG Supply System

6.3.1 Gas Tanks and Accessories

6.3.1.1 The gas tanks are to be installed in an independent gas tank space with permanent fixing means to ensure they can not fall during the sea voyages and can be easily dismantled and exchanged. The collision rubber or wood packing is to be provided between gas tank and fixed seating.

6.3.1.2 Effective and reliable working of gaseous and liquid phase joint elements and liquidometer are to be taken into consideration for the installation direction and location of gas tanks.

6.3.1.3 Gas tanks are as far as possible apart from heat sources to avoid direct sunlight. In general, the temperature of gas tank special holds or gas tank compartments is not to be more than 45 ℃ , and suitable cooling means is to be provided in summer.

6.3.1.4 The metering valve of gas tank is to automatically stop charging when the LPG charging capacity achieves 80% volume of gas tank.

6.3.1.5 The safety valve of gas tank is to ensure the pressure not exceeding its design pressure.

6.3.1.6 The sealed protective box is to seal the opening of gas tank and its accessories reliably and vent pipe is to be provided to lead the leakage gases to safe spaces outboard.

6.3.1.7 The gas tanks and accessories are to comply with the relevant requirements of GB[①], the products are to have the approved certificates of the authorities concerned.

6.3.2 LPG Control Equipment

6.3.2.1 Each LPG supply system is to be provided with an evaporation pressure regulator, which is to be capable of supplying suitable and rated working pressure for each gas-driven engine. The pressure within the pipelines after LPG passes through the evaporation pressure regulator is not to be more than 0.005 MPa.

6.3.2.2 Each outlet of gas tank is to be provided with flow-limiting valve which is automatically closed when the pressure deficiency between two ends of the valve is 0.35 MPa.

6.3.2.3 Automatic stop valve is to be provided in way of inlet of evaporation pressure regulator for LPG supply pipe main, and it can automatically cut off LPG supply in the following cases:

(1) ignition switch is not on;

(2) engine is not operated;

① Refer to GB17259.

(3) exhaust blower is not operated.

6.3.2.4 For the LPG supply system with more than one gas tank, stop valve is to be provided in supply pipe branch of each gas tank for use when gas tanks are exchanged.

6.3.2.5 For supply system simultaneously supplying for more than one engine, stop valve is to be provided in way of inlet pipe of each engine.

6.3.2.6 The gas tank is to be provided with capacity measuring means, pressure sensor and capacity indicator so as to show its present capacity in the bridge room.

6.3.3 LPG Supply Piping

6.3.3.1 The rigid drawn copper tube or drawn stainless tube is to be used for rigid supply pipe. For the pipelines with outer diameter of 12 mm and below, the thickness is not to be less than 0.8 mm, for those more than 12 mm, the thickness is not to be less than 1.5 mm. The approved rubber hose may be to use for low pressure pipelines after the evaporation pressure regulator, however, plastic hose is not to be used.

6.3.3.2 The high pressure supply pipelines from gas tank to evaporation pressure regulator are to be installed within enclosed or semi-closed gas tank spaces. Where it is installed in an open space, protective members are to be used for fixing and sheltering so as to prevent from stepping on or collision.

6.3.3.3 LPG supply pipelines are not to penetrate passenger cabins, service spaces and control stations.

6.3.3.4 The approved rubber hoses are to be used for connection between LPG engine and any permanently installed metal pipelines so as to avoid failure caused by vibration.

6.3.3.5 Where hose is used partially in supply pipeline, double clamps are used for the joint at both ends of hose and the clamps are to have a certain contacting length, no pinch-cock clamps are permitted to use and the clamps are to be so fitted as to be accessible.

6.3.3.6 The partial pipelines which gas may possibly leak in LPG supply pipelines are to be apart from electrical equipment as far as possible.

6.3.3.7 The LPG supply pipe is not to contact directly with bulkhead or deck and avoid contacting in way of the intersection of other pipelines.

6.3.4 Test

6.3.4.1 Hydraulic and tightness tests are to be carried out for LPG piping, the test pressure is in accordance with the requirements of Table 6.3.4.1.

Test pressure **Table 6.3.4.1**

LPG piping	Test pressure	
	Hydraulic test (in workshop) (MPa)	Tightness test (onboard) (MPa)
Pipeline from gas tank to pressure regulator	3.3	2.2
Pipeline from pressure regulator to engine	0.2	0.1

6.3.4.2 Effectiveness test is to be carried out after the installation of LPG supply system and no gas leakage exists. The tightness test mentioned in 3.4.1 may also be carried out together with effectiveness test.

Section 4 Arrangement and Ventilation

6.4.1 Arrangement

6.4.1.1 Engine room and gas tank space are to be independent from each other and it is prohibited to arrange them with passenger cabins. The gas tank space is to be as far as possible arranged in a place with good ventilation above deck by a semi-enclosed way. The gas tank space is to be capable of being locked to prevent persons other than the staff from touching and removing. No holes and stairway openings leading to the holds below are permitted to provide in the gas tank spaces. The distance from the gas tank and high pressure pipeline on deck to the outline edge of the boat (excluding fenders) is not to be less than 100 mm.

6.4.1.2 The engine rooms and gas tank spaces are to be provided with independent drainage systems and the drainage systems are to be separated from those in other compartments.

6.4.1.3 The bottom structures of engine rooms and gas tank spaces are to keep gastight and platforms are to be provided as far as possible. For bottoms with strengthening stiffeners, the arrangement is not to impair the drainage of combustible gases.

6.4.1.4 The bulkheads between engine room, gas tank space and passenger cabins and the bulkheads between gas tank space and engine room are to keep gastight, and in general, openings are not to be provided. Where it is necessary for the pipelines or cables are to penetrate the bulkheads, airtight is to be kept in way of the penetration and structural fire integrity is to be ensured.

6.4.1.5 For open yacht with windows and doors of non-weathertight type in passenger cabins, drainage groove and bilge well are to be provided in the bottom plating of passenger cabins.

6.4.2 Ventilation

6.4.2.1 Mechanical ventilation system having sufficient capacity is to be provided in enclosed or semi-enclosed engine rooms or gas tank spaces with the air charge ratio not less than 30 times/h and 20 times/h respectively. The mechanical ventilation in engine room is to be realized by interlocking start/operation with the main engine, i.e. after the blower is operated at least 4 min, the engine is started, where the blower is stopped caused by some reasons, the engine can be automatically stopped and the following requirements are to be complied with:

(1) In general, mechanical ventilation system is to be used in enclosed engine room and gas tank space. Each intake duct for an exhaust blower is to be under 1/3 height of the compartment and above the normal level of accumulated bilge water. The exhaust outlet is to be so arranged as to discharge the air in compartments to outboard and as far apart from the outlet of exhaust pipe for engine as possible. Where the exhaust outlet is near waterline, means to prevent water flooding is to be provided.

(2) Where mechanical blast is used for ventilation system, in general, the exhaust outlet is to be under 1/3 height of compartment and above the normal level of accumulated bilge water. The exhaust outlet is to be so arranged as to discharge the air in compartments to outboard and as far apart from the outlet of exhaust pipe for engine as possible. Where the exhaust outlet is near waterline, means to prevent water flooding is to be provided.

(3) The blower is to be of the non-spark type.

6.4.2.2 In general, natural ventilation is also to be provided in the engine room and gas tank space mentioned in 6.4.2.1 above. The inlet is to be as far apart from the outlet as possible. The exhaust outlet is to be under 1/3 height of compartment and above the normal level of accumulated bilge water. The exhaust outlet is generally of shutter type.

Section 5 Detection and Alarm System

6.5.1 LPG combustible fume detector

6.5.1.1 The LPG combustible fume detection system is to be subject to approval by the Society.

6.5.1.2 Fixed LPG combustible fume detector are to be provided in enclosed and semi-enclosed gas tank spaces and enclosed engine room.

6.5.1.3 LPG combustible fume detectors are to be so arranged to meet the following requirements:

(1) Probes are to be provided in a position where LPG combustible fume leaks and accumulates easily.

(2) Where the concentration of LPG combustible achieves 30% lower limit of explosion, visual and audible alarm is to be given in the bridge, where it achieves 60% lower limit of explosion, manifold on LPG supply main may be automatically cut-off or remotely cut-off in the bridge.

6.5.1.4 Each shipping company is to provide at least one portable LPG combustible fume detector in watch-keeping room on wharf, which is available for use by crew.

Section 6 Structural Fire Protection and Fire Extinguishing Apparatus

6.6.1 Structural fire protection

6.6.1.1 The side of separating bulkheads facing fire hazard zone between engine room, gas tank space and passenger cabin and between gas tank space and engine room is to be made of FRP having flame-retardant performance or equivalent materials.

6.6.1.2 Coating and insulation which may set easily fire and emit large amount of smoke or noxious gases during burning can not be used in engine room and gas tank space.

6.6.1.3 Prominent “No Smoking” signs are to be posted in engine room and gas tank spaces.

6.6.2 Provision of fire extinguishers

6.6.2.1 Engine room is to be provided with fire extinguishers as required in Table 6.6.2.1.

Provision of fire extinguishers in engine room Table 6.6.2.1

Total power in engine room P (kW)	Provision of fire extinguishers
$P \leqslant 37.5$	One dry powder fire extinguisher with a capacity not less than 2 kg
$37.5 < P \leqslant 150$	Two dry powder fire extinguisher with a capacity not less than 2 kg each
$150 < P \leqslant 300$	Two dry powder fire extinguisher with a capacity not less than 3 kg each
$300 < P \leqslant 450$	Two dry powder fire extinguisher with a capacity not less than 4 kg each

6.6.2.2 At lest two dry powder fire extinguishers with a capacity not less than 2 kg each are to be provided in a gas tank space.

Section 7 Miscellaneous

6.7.1 Electrical equipment in gas tank space

6.7.1.1 Electrical equipment is not to be installed in gas tank space as far as possible. Where it is needed, electrical equipment preventing LPG combustible fume from igniting is to be provided. Where it is necessary, one portable explosion-proof light with batteries is to be provided in emergency use onboard the boat.

6.7.2 Operation Requirements

6.7.2.1 Boat's certificate and/or operation manual of LPG power-driven system, etc. required in the Rules are to be provided onboard the boat.

6.7.2.2 The crew is to be trained for normal operation and management of LPG power-driven system.

6.7.2.3 The crew is to be trained for emergency procedures in order to deal with the emergency cases such as LPG leakage or fire.

6.7.3 Accessing spaces

6.7.3.1 When the crew accesses a compartment, void space or other enclosed spaces where LPG is likely to accumulate, one of the following means is to be taken:

(1) fixed or portable LPG detecting device is to be used to confirm that no dangerous concentration of LPG combustible fume exists in the air of the above-mentioned spaces;

(2) respirators and other necessary protective equipment are to be provided for personnel.

6.7.3.2 Where personnel access the above-mentioned spaces, any potential fire source can not be brought in, unless it is verified that free gas is carried out for the space and it is still kept in such a condition.

6.7.4 Operation Manual of LPG Power-Driven System

6.7.4.1 Operation Manual of LPG Power-driven system approved by the Society is to be readily available onboard, and it is used as safe operation guidance in normal conditions and in emergency.

6.7.4.2 The Operation Manual is to contain at least the following.

6.7.4.3 The starting procedures of LPG engine is to comply with the following requirements:

(1) to switch on detection and alarm system to confirm no LPG leakage, where LPG leakage is detected in engine room (sometimes) and gas tank space by the probe, examination is to be made immediately to find the leakage reason and handle with it;

(2) to switch on blowers in engine room and gas tank space;

(3) in order to prevent mal-operation, interlocking device is to be provided between blower and engine. After the blower is operated more than 4 min, the engine can be started, where the blower is stopped caused by some reasons, the engine can be automatically stopped.

6.7.4.4 During the boat's service period (including embarkation, disembarkation or temporary laid-up), mechanical ventilation is to be kept in the enclosed or semi-enclosed engine room and gas tank spaces and blower can not be stopped.

6.7.4.5 Fixed LPG combustible fume probe is to be provided onboard the boat. Where the concentration of LPG combustible fume achieves 30% lower limit of explosion, visual and audible alarm is to be given in the bridge, where it achieves 60% lower limit of explosion, manifold on LPG supply main may be automatically cut-off, if it fails, the navigating officer must cut-off the LPG supply main immediately in the bridge.

6.7.4.6 Changing of gas tanks

(1) After recharged, the gas tank and its accessories are to be examined whether it leaks or not, if found damage and leakage, the gas tank can not be onboard.

(2) After it is installed onboard, the connection between outlet valve and quick connection of gas tank is to be examined, leakage is not to be found there.

6.7.4.7 Other requirements

(1) Where it is found the LPG supply system leaks, it can not be used before the cause is determined and repair is made, means are to be taken to cut off LPG supply source, start the blower, various fire sources are prohibited and electrical equipment is not to be used.

(2) It is prohibited to discharge, store or deal with the LPG residual liquid in gas tanks onboard.

(3) All supply valves of LPG engine are to be closed during boat's laid-up.

(4) Where fire takes place onboard, the gas tanks are to be dismantled and thrown outboard quickly to protect the safety of boat and passengers.

(5) Special-assigned persons are to be responsible for the management, maintenance and service of LPG equipment.

Appendix: Requirements for preparation of boat's operation manual

A boat's operation manual is to include at least the following:

1. Brief introduction of boat, including boat's main scantlings, speed, category of service restriction, equipped machinery and electrical installations, communication equipment, signal equipment, fire-extinguishing apparatus, life-saving appliances, main engine power, oil/water capacity, endurance, complement, sewage equipment, etc.

2. Brief introduction of each system, including propulsion system, fuel oil system, steering system, ventilation system, bilge water system, electrical power system, fire-protection system, etc.

3. Key points for safe operation, including:

(1) speed limitation during navigating in wind waves;

(2) main engine speed limitation for preventing sudden drop of transverse stability during navigation with high speed;

(3) limitation of main engine speed when high speed boat in top speed turn;

(4) speed limitation in overtaking other boats;

(5) requirements for safe use of inboard and outboard engines or inboard engine boat with petrol/LPG, including requirements for maintaining natural air vents to be clear and for mechanical ventilation, etc.

4. Escape measures.

5. Requirements for routine maintenance, including main and auxiliary engines maintenance, regular inspections for fire-extinguishing apparatus, maintenance and inspections for ventilation equipment of petrol engine and petrol tank compartments.